LESSONS ON

ELEMENTARY HYGIENE

AND

SANITATION

WITH

SPECIAL REFERENCE TO THE TROPICS.

W. T. PROUT.

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BY

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INTRODUCTION.

THE following lessons were originally given as a series of six lectures, and have now been extended and illustrated so as to form an elementary text-book for the use of the schools in West Africa. I have still adhered to the lecture form, as being the style best adapted to convey the facts of sanitation to the class for whom the book is intended, in as simple and easy a manner as possible. It is not meant in any way to take the place of the many excellent handbooks on general sanitation, but my aim has been more especially to deal with the sanitary problems of tropical life, which differ so much from those of a temperate climate. I trust this little work will be found to fill to some extent the gap which undoubtedly exists in this direction at present.

W. T. P.

MEDICAL DEPARTMENT,
SIERRA LEONE,

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SYLLABUS.

LESSON I.

Introduction—Objects of Course.

Hygiene—The Science of Preserving Health.

Sanitation—The practical methods of doing so.

History of Sanitation—Sanitary laws among the ancients ; Sanitary laws of the Jews and other religious bodies ; Belief in Witchcraft and Poison as a cause of disease.

Effects of Improved Sanitation—A diminished death rate ; Decrease of Epidemics, such as plague and cholera in civilised countries ; Disappearance of certain diseases ; Vaccination and Smallpox.

Health—A condition when all the Organs of the body are doing their work properly and regularly, and when they are properly constructed.

Disease—A departure from this condition.

Nature and Causes of Disease—A knowledge of the Cause necessary before prevention can be carried out ; Improved methods of Investigation ; Microscopes, etc.

LESSON II.

THE HUMAN BODY.

General Structure.—The **Head—Cranium.**
Face—organs of sense, nose, ears, eyes, and mouth.
Thorax—formed by ribs, diaphragm, and
The **Trunk**—vertebral column ; contains the heart, and lungs.
Abdomen—contains the stomach, bowels, liver, spleen, and kidneys.
Extremities—Upper—for grasping.
Lower—for support and locomotion.

The **Organs** of the Body divided into Groups or Systems.

1. The **Osseous or Bony System.**
Serves two purposes—1st. Acts as a support.
2nd. Protects internal organs.
Joints. Ligaments. Cartilage.
Skull—Cranial bones immovable.
Face bones immovable except lower jaw.
Vertebral Column—Ribs. Breastbone.
Pelvis.
Bones of Upper Limbs.
Bones of Lower Limbs.
Composition of Bones—Inorganic or Mineral.
Organic or Animal

2. The **Muscular System.**
Muscle—Involuntary—Heart. Stomach, etc.
Voluntary—Limbs and Trunk.
Structure of Muscle—Bundles of small fibres frequently end in Tendons.
Functions of Muscles—Movement and Locomotion.
Keeping the Body in the erect position.

3. The **Circulatory System.**
Heart—A force pump enclosed in Pericardium.
Divided into **Right Auricle ; Left Auricle.**
Right Ventricle ; Left Ventricle.
Venæ Cavæ open into Right Auricle.
Tricuspid valve—between Right Auricle and Right Ventricle.
Pulmonary Artery—leaves Right Ventricle ; Semi-lunar valves.
Pulmonary Vein—enters Left Auricle.
Mitral valve—between Left Auricle and Ventricle.
Aorta—leaves Left Ventricle ; Semi-lunar valves.

Blood Vessels. Arteries. Veins. Capillaries.
Blood—Plasma.
Red Corpuscles—Oxygen Carriers.
White Cells—Scavengers.

Circulation of the Blood—Pulmonary Circulation.
Systemic Circulation.

LESSON III.

THE HUMAN BODY—*continued.*

4. The **Alimentary or Digestive System.**
   Stomach and Bowels.
   Digestion.

5. The **Absorbtive System.**
   Lymphatics.

6. **Respiratory System.**
   Lungs.

7. The **Excretory System.**
   Waste Products are removed by the process of **Excretion.**
   Organs of Excretion—Alimentary Canal.
   Lungs.
   Kidneys.
   Skin.
   Kidney. Ureter. Bladder.
   Structure of Kidney—Cortex, Medulla, Pelvis.
   Tubules of Kidney ; Secrete urine.
   Composition of Urine.

8. The **Integumentary System.**
   Skin—Epidermis—Horny Layer / Malpighian Layer } The protective Layer.
   Dermis.—Papillæ. The Tactile Layer.
   Sweat Glands—Pores.
   Insensible perspiration.
   Sensible perspiration.
   Composition of Sweat.
   Sebaceous Glands.
   Hairs.
   Nails.
   Functions of Skin—A protection to the part underneath.
   An organ of touch.
   An excretory organ.
   Regulates the temperature.

9. The **Nervous System**—The great Directing System.
   Brain contained in the Skull.
   Spinal Cord contained in the Vertebral Column.
   Nerves, Motor, Sensory.
   Special Nerves of Sense, Sight, Taste, &c.

LESSON VI.

ANIMAL PARASITES—MALARIA.

Malaria—

Distribution—Found all over the world ; Deaths due to fever in Freetown ; Children suffer more than adults from malaria.

History—Discovery of malarial parasite by Laversan, 1880. Dr. Manson's theory that it was carried by mosquitoes ; Theory proved by Dr. Ross.

Experiments of Dr. Manson—(*a*) Experimental transmission of fever to healthy persons in London by means of infected mosquitoes from Rome ; (*b*) Observers in mosquito-proof house in unhealthy district near Rome do not contract fever.

Description of malarial fever—Varieties ; Malarial cachexia in children.

The Parasite in the human body—Description of parasite of benign fever ; Young form attacks red blood cells, grows, and forms black pigment—"Melanin" ; Begins to divide and forms spores, rosette form—"Sporocytes" ; Spores liberated and again attack red cells.

Malignant parasites similar, but slight differences.

Sexual forms—"Gametocytes" ; Round spheres in benign fever ; Crescents in malignant fever ; Form flagellæ ; Crescents and spheres very persistent in body.

The Parasite outside the human body—Grows in mosquito ; Salivary glands ; Salivary juice ; Malaria carried by a special mosquito, the Anopheles ; Differences between Culex and Anopheles ; Development of mosquito—larvæ, pupæ, adult mosquito ; Growth of parasite in mosquito ; Sexual forms, absorbed along with the blood, form bodies called "Zygotes" in the stomach wall ; Zygotes become filled with needle-like bodies—"germinal rods" ; Zygote bursts and germinal rods find their way to salivary glands, and are injected into the human body along with the salivary juice.

Effects of malaria on body—Anæmia ; Melanin in organs.

LESSON VII.

TREATMENT AND PREVENTION OF MALARIA.

In the body—Quinine—a native remedy; Effect of quinine on the malarial parasite; Quinine as a preventive in children and adults; Is Quinine properly used harmful? No.

Outside the body—Mosquito nets should be constantly used.
Mosquito proof rooms and houses.
The Basil Plant (tea bush) quite useless.

Destruction of Mosquitoes—
All vessels containing water to be regularly emptied.
All water vessels to have proper covers.
Remove all tin pans and old bottles.
Clear out and fill up all pools in yards.
Close wells and cesspits.
Put the street gutters in order.
Stand pipes should be properly drained.
Attend to the water courses.
Use of kerosene.

Various **difficulties in connection with the Mosquito theory.**

LESSON VIII.

ANIMAL PARASITES—*continued.*

Sleeping Sickness—Caused by trypanosoma; Carried by Tsetse fly.

Filaria—Cause of elephantiasis; Geographical distribution; Very prevalent in this country; Diseases produced by Filaria—Elephantiasis, chyluria, swelling of glands, abscesses, etc.

Varieties of Filaria—*F. Nocturna*, *F. Diurna. F. Perstans.*

Development of the Filaria; In the body; Outside the body; Grows in the mosquito culex; Goes back into the human body by the proboscis or trunk.

Prevention of Filariasis same as Malaria—Destruction of mosquitoes.

Yellow Fever—Distribution; A very dangerous disease; Carried by a special mosquito, the *Stegomyia Fasciata,* which is very prevalent here; Prevention.

Intestinal Parasites—Tape worm; Tænia; Life history—Adult in man; Intermediate stage in some lower animal; Adult; Eggs; Proscolex; Bores through stomach wall of animal; Forms cysticercus; Eaten by man; Again forms adult worm.

Tænia Solium—Pig tape worm.
Tænia medio canellata—Beef tape worm.
Bothriocephalus latus—Fish tape worm.

Sometimes the intermediate stage occurs in man and the adult in a lower animal; Forms "Hydatids" in man; Very dangerous.

Prevention—Inspection and destruction of infected meat; Meat should be well cooked; Proper disposal of excreta.

Round Worm—History—Eggs get into world by excreta; Get into drinking water or on vegetables and are then swallowed; Prevention.

Thread Worms—Generally in children, who re-infect themselves by dirty habits.

Ankylostoma—A serious disease; Exists in Sierra Leone; Lives in the bowels and sucks the blood; History—Eggs, damp ground, small worm, human stomach; Gains admission by drinking muddy water or by eating with dirty hands.

Trichina—A disease got from pigs through eating imperfectly-cooked pork; Worm lies coiled up to muscle; Prevention—See that all pork, ham or sausages are properly cooked.

Flukes—Grow in kidneys, liver, etc.; History—Man, water, fresh-water, insect water, man; Blood fluke causes hæmaturia; Found in this country.

Guinea Worm—Grows especially in limbs; Forms abscesses; Eggs live in water. Get into a small water insect; thence into a man by drinking water; Prevention—A pure water supply.

Jiggers or **Chigoes.**

Flies—Tumbo Fly.

Craw-Craw or **Itch.**

LESSON IX.

THE DIGESTIVE SYSTEM.

The **Mouth—Teeth;** Milk teeth; Permanent teeth.
Structure of teeth; Importance of thorough mastication.

The **Salivary Glands**—Composition of **Saliva;** Action of Saliva.
Ptyalin transforms starch into sugar.

The **Œsophagus.**

The **Stomach—Structure** of; Peritoneum.
Muscular layer.
Mucous membrane, peptic glands.

Secretion of peptic glands; **Gastric Juice.**

Composition of Gastric juice; **Pepsin,** a ferment, has the power of changing proteids into peptones.

Chyme.

Small Intestine—Structure—Peritoneum.
Muscular.
Mucous. **Villi;** Lacteal; Tubular glands.

Large Intestine—Ileo-cæcal valve;
Ascending; Transverse and descending Colons.

Rectum—Anus.

Liver—Situation—Vessels—Hepatic artery.
Hepatic vein.
Bile duct; Gall bladder.
Structure—Composition of **Bile;** Emulsification.
Function—To secrete bile.
To store up Glycogen.

Pancreas—Situation—Functions—Secretes **pancreatic juice.**
Contains three ferments: One acting on starch; One acting on proteids, One breaking down fats.

Intestinal Digestion—Chyle; Peristaltic action.

Excretion.

The **Lymphatic System—Thoracic duct;** Lymphatic Capillaries; Lymphatic Glands.
Lymph, composition of.

Spleen—Situation; Function.

LESSON X.

FOOD.

Necessity for Food.

Uses of Food.—(1) Production of energy; (2) The repair of waste; (3) The building up of new tissues; (4) The production of heat.

Composition of the Human Body—Two-thirds water.
One-third chemical elements.

Organic Compounds—Non-nitrogenous; Fats; Amyloids.
Nitrogenous; Proteids.

Mineral Matter—

Daily loss of the Body—4,500 grains Carbon, 300 grains Nitrogen.

Classification of Foods—
Organic: Nitrogenous (flesh-formers)—Meat, eggs, milk, peas, etc.; Non-nitrogenous (heat and force producers); Hydrocarbons—oils and fats; Carbohydrates—starch and sugar.
Inorganic: Salts—phosphates, chlorides, etc.; Gases—oxygen, nitrogen; Water.
Uses of the different kinds of Food.

Description of the different kinds of Food—
Nitrogenous: Beef; Eggs—A good natural food; Milk—Contains all the elements necessary to support life; Wheat, flour, bread, maize or Indian corn, agidi, ogie, peas, beans, akara.
Non-nitrogenous: Yam, foofoo, cassava, butter, lard, palm-oil, ground-nut oil, doney, etc., sugar; Vegetables—spinach, greens, sorrel: krane-krane, okro, etc.; Condiments—pepper, mustard, kindah, ogiri.

A Mixed Diet required—Requirements of a proper diet; Foundation English diet; Specimen native diet.

Diseases connected with Food—Parasitic—Tape worm, trichina, etc: Excess of food—Disorders of digestive system; Insufficiency of food—starvation, wasting; Scurvy.

Time of taking Food—Regularity advisable.

Cooking of Food—Different methods; Advantages and disadvantages.

Beverages—Non-intoxicating—Tea, coffee, cocoa.
Intoxicating—Wine, beer, brandy, whisky.
Action of **Alcohol**—First stimulating, then depressing.
Evil effects of the habitual use of Alcohol.
Alcohol not a food, and not a necessity.

LESSON XI.

WATER.

Uses of Water—Drinking ; Cooking, Bathing, etc.

Amount of water required—Minimum, 15 gallons per head.

Composition of water—Exists under different forms ; Watery vapour ; Mists ; Clouds ; Rain ; Hail ; Snow.

Characteristics of good water—

Sources of water—**Rain water**—a pure supply.

Springs—a good water if uncontaminated.

Surface wells—may be safe in the country ; dangerous in towns ; easily contaminated by cesspits.

Deep wells—a good supply.

River or **stream water**—good if uncontaminated.

Upland surface water—good.

Impurities in water—Mineral ; Organic ; Vegetable matter ; Sewage ; Eggs of animal parasites.

Purification of water—Boiling ; Filtration.
All water vessels to be protected.

LESSON XII.

AIR—RESPIRATION.

The **Respiratory System**—The mouth or **nose**.
The **Pharynx**.
The **Trachea** or windpipe.
The **Larynx**.
The **Lungs**—The Bronchi.
Bronchioles.
Air cells.
The **Pleura**, the outside lining membrane.

Respiration—
Inspiration—The drawing of air into the lungs.
Expiration—The forcing of air out of the lungs.
Tidal Air—Supplemental air; Residual air.

Changes in air during Respiration—

Composition of air—

Changes in the blood—Oxygen taken up.
Carbonic Acid given out.

Changes in the air—Oxygen diminished.
Carbonic Acid increased.
Organic matter and water added.

Effect of breathing impure air—Headache; Sleepiness; Suffocation; Consumption and other lung diseases.
Evils of breathing Sewer gas.

Purification of air—Effected by **plants**.
Winds.
Diffusion of gases.
Differences of temperature.
Rain.

Ventilation—Keep the windows open; 3,000 cubic feet of air per hour required by each person; For effective ventilation two openings required, an inlet for fresh air, and an outlet for foul air.

LESSON XIII.

THE DWELLING.

Requirements of a good house—

1st. A dry **site**; Necessity for surface drainage; Advantages of paved yards.

2nd. A plentiful supply and frequent removal of **water.**

3rd. A satisfactory system of **sewage removal;** Danger of the cesspit system; Closure of all cesspits.

Methods of sewage removal; **Water carriage system.**

Conservancy—(*a*) **Cesspit.**
(*b*) **Midden.**
(*c*) **Pail.**
(*d*) **Dry Earth.**

The pail system most suitable for the West Coast.

Disposal of solid refuse.

4th. A system of **ventilation.**

5th. A condition of **house construction** which ensures perfect dryness of the foundation, walls and roof.

Laying out of towns—Necessity for wide streets and open spaces.

LESSON XIV.

CLOTHING.

Uses—1st. To protect the body from injury.
2nd. To preserve the temperature of the body.
3rd. For purposes of ornament.

Value of clothing material depends upon conducting properties.

Properties of clothing—
Should absorb perspiration.
Should be light.
Should be loose.
Should be porous.

Materials for clothing—
Silk a good material but expensive.
Wool most suitable for a warm climate.
Cotton cool, but unabsorbent.

Colours—Light colours most suitable for a warm climate.

Amount—Children, the old and feeble should be well protected.

Cleanliness of clothing—Frequent washing necessary.

PERSONAL HYGIENE.

Food.

Alcohol.

Tobacco, harmful in youth.

Personal cleanliness—Free use of soap and water.

Teeth should be brushed daily.

Bowels should be opened regularly.

Exercise should be regular and systematic.

Sleep—About seven or eight hours required.

CONCLUSION.

LIST OF ILLUSTRATIONS.

LESSONS
ON
ELEMENTARY HYGIENE AND SANITATION.

LESSON I.

INTRODUCTORY—HEALTH AND DISEASE.

THE subject of Hygiene and Sanitation is one, the importance of which is now universally recognised; and in the following lessons, I propose to draw your attention, not only to the general principles, but more particularly to those facts which bear special reference to the tropics, and to that part of them in which we happen to live, West Africa.

In bringing this subject before you, I shall endeavour to do so as plainly as possible. I shall avoid as far as possible those technical expressions and words which medical men find it necessary to use to describe accurately the diseases with which they have to deal, and when I have to do so from time to time, I shall explain them to you as fully as possible, and if at any time I tell you anything which you are unable to understand, I shall be very glad if you will come to me at the end of the lecture and tell me your difficulties. If, on the other hand, some of you find that I am at times too elementary and simple, I trust that you will pardon me, for I must assume that a large number of you are quite ignorant of the subject.

I shall try to place before you only those facts relating to disease and its prevention which are definitely proved and accepted, and as in the course of these short lessons I shall not be able to tell you in all cases how the results are arrived at, I shall have to ask you to take my word for them, and to extend to me that belief which you give to your teachers in other walks in life. I hope to be able to tell you something of the nature and causes of Disease, to actually show you some of the parasites which produce disease, and to point out to you how to prevent them from getting into your bodies. I hope to tell you something about the air you breathe, the food you eat, the raiment with which you are clothed, and how to take care of your bodies; and when I have finished I trust that you will have learned and remembered enough to enable you by word and example to spread the knowledge among your

fellow-inhabitants, and thus help to make this city and country more healthy ; and let me tell you, that it is my opinion, and has been for years past, that this City of Freedom, which has a world-wide reputation for unhealthiness, can be made as healthy as most European cities. But this ideal cannot be attained by sitting down with our arms folded. We must all put our hands to the plough, and be prepared to work and to make sacrifices in order to take advantage of the knowledge of sanitary laws which Science has provided for us. I am sure that I shall not appeal in vain to you for your assistance.

HYGIENE AND SANITATION.

And in the first place it would perhaps be as well to clear the ground a little and to ask, What are we to study? What is Hygiene? What is Sanitation? **Hygiene** may be defined as *the science of preserving health*, Practical Hygiene or **Sanitation** as the *practical methods by which this is carried out*. The word " Hygiene," as you know, is a French word, and is derived from the Greek word *Hygeia*, " the goddess of health." Similarly "Sanitation " is derived from a Latin word meaning healthy.

HISTORY.

The preservation of health and the prolongation of life have been the objects of research for thousand of years. You have all heard of the " Elixir of life," of the vain researches of ancient philosophers for that mysterious fluid which was to have the power of preserving everlasting youth and giving eternal life. We know now that this is a wild dream, that the universal laws of nature are that everything must be produced, run its appointed course, and finally decay and die; but Science is now showing us methods by which we can alter the conditions under which life is carried on, and if we cannot prolong it indefinitely, we can at least remove some of the causes which produce death, and thus prolong it very considerably.

AMONG THE ANCIENTS.

We find traces of attempts at sanitary laws dating many thousands of years back. Fragments are to be found among certain Babylonish records recently discovered, dating back nearly 6,000 years, and in the laws of Moses, as is very well known, very elaborate directions are given as to the preservation of health in connection with personal cleanliness,

the isolation of the sick, and the prohibition of certain articles of food—laws which are still carried out by the Jews with great benefit to themselves ; and it is a remarkable fact that, throughout the whole of their history, the Jews have shown a remarkable immunity from the ravages of epidemic disease, and suffered to a much less extent than the Christians, during the terrible epidemics which devastated Europe during the Middle Ages. As an example of the sanitary rules to be found in the Bible I may quote the following :—

In Leviticus, Chapter xi., we find laid down the different kinds of food which may or may not be eaten.

The following extracts show how the Jews dealt with a disease which they considered to be communicable, namely leprosy, and even at the present day, there is little to add to these precautions :—

LEVITICUS, *Chapter xiii.*

Verse 3. And the priest shall look on the plague in the skin of the flesh : and when the hair in the plague is turned white, and the plague in sight be deeper than the skin of his flesh, it is a plague of leprosy : and the priest shall look on him, and pronounce him unclean.

Here the priest, who was the doctor in those days, examines the patient, decides that he is suffering from leprosy, and pronounces him "unclean." But sometimes, the cases are doubtful at first, and accordingly *isolation for purposes of observation* is provided for :—

Verse 4. If the bright spot be white in the skin of his flesh, and in sight be not deeper than the skin, and the hair thereof be not turned white ; then the priest shall shut up him that hath the plague seven days :

Verse 5. And the priest shall look on him the seventh day : and, behold, if the plague in his sight be at a stay, and the plague spread not in the skin ; then the priest shall shut him up seven days more :

Then the priest comes to the conclusion that it is not leprosy, and he is pronounced "clean."

Verse 6. And the priest shall look on him again the seventh day : and, behold, if the plague be somewhat dark, and the plague spread not in the skin, the priest shall pronounce him clean : it is but a scab : and he shall wash his clothes, and be clean.

But other cases are not so fortunate, the disease is seen to be spreading, and at last the priest gives the pronouncement, he is "utterly unclean :"—

Verse 7. But if the scab spread much abroad in the skin, after that he hath been seen of the priest for his cleansing, he shall be seen of the priest again :

Verse 8. And if the priest see that, behold, the scab spreadeth in the skin, then the priest shall pronounce him unclean : it is a leprosy.

Verse 44. He is a leprous man, he is unclean ; the priest shall pronounce him utterly unclean ; his plague is in his head.

Then comes the terrible sentence, complete and solitary *isolation*, an isolation unaccompanied by any of the comforts, and ameliorations with which we now surround such cases :—

Verse 45. And the leper in whom the plague is, his clothes shall be rent, and his head bare, and he shall put a covering upon his upper lip, and shall cry, Unclean, unclean.

Verse 46. All the days wherein the plague shall be in him he shall be defiled ; he is unclean : he shall dwell alone ; without the camp shall his habitation be.

But it was also recognised that the disease can be communicated in other ways than by personal contact, and accordingly *disinfection, or destruction of clothing* is provided for :—

Verse 51. And he shall look on the plague on the seventh day : if the plague be spread in the garment, either in the warp, or in the woof, or in a skin, or in any work that is made of skin ; the plague is a fretting leprosy ; it is unclean.

Verse 52. He shall therefore burn that garment, whether warp or woof, in woollen or in linen, or anything of skin, wherein the plague is : for it is a fretting leprosy ; it shall be burnt in the fire.

Then we find that in the cases where recovery takes place, the *Disinfection of the Individual* must take place.

LEVITICUS, *Chapter xiv.*

Verse 8. And he that is to be cleansed shall wash his clothes, and shave off all his hair, and wash himself in water, that he may be clean : and after that he shall come into the camp, and shall tarry abroad out of his tent seven days.

Verse 9. But it shall be on the seventh day, that he shall shave all his hair off his head and his beard and

his eyebrows, even all his hair he shall shave off: and he shall wash his clothes, also he shall wash his flesh in water, and he shall be clean.

Very rigorous measures, too, were prescribed for the *treatment of infected houses*:—

Verse 40. Then the priest shall command that they take away the stones in which the plague is, and they shall cast them into an unclean place without the city:

Verse 41. And he shall cause the house to be scraped within round about, and they shall pour out the dust that they scrape without the city into an unclean place:

Verse 42. And they shall take other stones, and put them in the place of these stones; and he shall take other mortar, and shall plaister the house:

Verse 43. And if the plague come again, and break in the house, after that he hath taken away the stones, and after he hath scraped the house, and after it is plaistered:

Verse 44. Then the priest shall come and look, and behold, if the plague be spread in the house, it is a fretting leprosy in the house: it is unclean.

Verse 45. And he shall break down the house, the stones of it, and the timber thereof, and all the mortar of the house; and he shall carry them forth out of the city into an unclean place.

This association of religious observances with certain sanitary regulations is not confined to the Jews, for among Mahomedans, Hindus, and others, the frequent ceremonial ablutions and purifications have undoubtedly a beneficial sanitary effect, though in many instances, as in India, this effect is counteracted by the filthy surroundings in which people live.

I think I have said enough to show that the necessity for sanitary regulations has been long recognised, but unfortunately the want of exact knowledge of the causes of disease in the past, has made it impossible for these measures to be properly and rationally applied.

WITCHCRAFT.

Now, this want of knowledge has led to a curious but not wholly unnatural result, namely: that obscure diseases, and epidemics, have been attributed to witchcraft, or to the visitation of God, against which it was useless to struggle;

and to the present day in this country there is a very persistent and deep-rooted belief in witchcraft, as a means of producing disease, and even death. When people here see some one dying of a disease which is not familiar to them, or which has some strange or unusual symptoms, there are two things to which the death is put down—one is poison and the other is witchcraft. Let me give you an example :—When an elderly man bursts a blood vessel in his brain, certain symptoms are produced which, to the untrained eye, are very strange and startling. The man may fall down suddenly, he loses the power of moving his arm or leg, his mouth becomes twisted, and he is unable to speak. Now, it seems very unaccountable that all this should happen to a man who was walking about quite well a few minutes before, and I don't know how many times I have heard this attributed to witchcraft, the work of some personal enemy. But a doctor knows that these signs can all be explained in a perfectly natural way, namely, the blood pouring out through the broken tube inside the brain. And so, in many other cases, I have heard deaths talked about as being due to poison, which were perfectly natural. Well, I am not surprised at the persistence of this belief, for even in Great Britain and Europe, places which have had more advantages than you have had, superstition still exists. But so far as disease is concerned, it is becoming less and less every day for this reason—that superstition flourishes where there is ignorance, and our knowledge of the causes of disease is becoming more and more extensive every day. If, then, we actually know the cause of a disease, we cannot say that it is due to witchcraft or even to poison, so that when a doctor, who has been specially trained to ascertain the causes of disease, tells you definitely that a disease is due to a certain thing, it is your duty to believe him, and to try to discourage the idea that it may be due to witchcraft. Belief in witchcraft as a means of producing disease, causes a great deal of harm in this way, that it takes the mind away from the real causes and thus prevents their being remedied. A single one of the sanitary precautions of which I shall tell you shortly, will do more to drive away disease, than days of beating of tom-toms and incantations, and I trust that by the time these lessons are finished, you will agree with me that the truths of Science are much more wonderful and powerful than witchcraft.

EFFECTS OF SANITATION.

But some of you may be asking—What practical benefit are we deriving from the increase in our knowledge of what

produces disease, and from improved sanitary measures? Is it productive of actual benefit? The answer is easy—it is shown in many ways. The death-rate of Europe and of England is slowly decreasing. Whereas in England in 1841–50, out of every thousand people 22·4 died, in 1891–5 there have only been 18·7 out of the same number. This means that people are healthier and are living longer.

Then we find that certain diseases have almost entirely disappeared, and that we no longer have those terrible epidemics which in the middle ages used to kill off so many myriads of people. Many of you have heard of the Black Plague which raged over Europe in the 14th century, killing hundreds of thousands of people. It visited London, whole streets were deserted, dead bodies were lying about the streets, and there were hardly enough people to bury them. Contrast this with what has happened recently. Plague, the same plague which existed years ago, is flourishing in India, and has been introduced more than once into England and Scotland. What has happened? There has been no epidemic, and the disease has been stamped out at once. We *know the cause*, and we are able to take steps to prevent its spread.

Take another terrible disease, Cholera. In 1884, 5,000 deaths occurred in France, 15,000 in Italy. It was introduced *three* times into England, but owing to the sanitary conditions of the towns and the precautions which were taken, there was no spread. Again in 1892 there was another epidemic; in Russia 132,000 died from the disease. It was introduced into England, but again there was no spread. Have you any idea of what the result of introducing cholera into Freetown would be with our present defective sanitary arrangements? I do not think that I am exaggerating if I say that it would kill from a tenth to a sixth part of the population.

Another very dangerous disease, produced by overcrowding—typhus, or gaol fever—is now so rare that very few doctors have seen it. Small-pox, too, that loathsome disease, which disfigures where it does not kill, has been much diminished, and where vaccination has been efficiently carried out, has almost disappeared.

HEALTH AND DISEASE.

These few examples which I have mentioned to you, will be enough to give you some idea of the benefits which sanitation may confer, and it is our object now to study the means by which these results have been attained, and to see how far we can apply them to ourselves and our surroundings.

And, as a preliminary, we must first get some idea as to what **Health** and **Disease** are. I suppose that you all think that you know when you feel well and when you are ill, and are astonished to think that health requires a definition, and yet I am quite sure that if I ask you what health is, the great majority could not tell me, and I am also sure that a great many people think themselves quite well, who are not really so. Well, you all know that the body is very complicated; it is made up of a great many parts, for example, the heart, the stomach, the lungs, the brain, the blood, and so on. **Health,** then, may be defined as *the condition when all these parts or organs* (as they are called) *are doing their work properly and regularly, and when they are all properly constructed.* **Disease,** on the other hand, may be simply defined as a *departure from this condition.* Let me try to illustrate this by a very familiar example—that of a steam-engine. All of you have looked down into the engine room of a steamer, or have seen one of the engines going along the rails in this town—the pistons work regularly, the parts are all well oiled, the wheels go smoothly round and round. That is *health*; the parts are properly constructed and working regularly. If, on the other hand, the supply of oil is neglected, or sand gets into a joint, or a rod gets bent, we notice a difference at once; the engine works slowly and irregularly, parts get overheated, and if not attended to it will finally break down and stop. That is *disease.*

And we find that in the human body, disease of one part affects the whole organism. You are all familiar with the fact that when the stomach is out of order you feel out of sorts, you are irritable, feel headachy, and generally make yourself a nuisance to yourself and to your friends. Or if the heart is diseased, the blood cannot be sent properly to all parts of the body; you suffer from breathlessness, the brain does not get enough blood, and you cannot do your daily work properly. Or, going a little further, when you have "fever" you all know the general feeling of weariness, the disinclination for work, the inability to take food, the aches and pains, all showing that your organs are not working as they ought to do. These, you are familiar with, as examples of health and disease, and when you remember that ill-health, if not attended to, finally tends to make the human engine break down altogether, and that final stop, which we call death, happens, you will understand how very important anything is, which will help us to diminish the amount of sickness in our midst.

Health means capacity for work, capacity for work means money, money means the well-being of the individual, the

ability to surround himself and his family with comforts, or even luxuries, and it also means the general prosperity of the community. Health means longer life, and consequently increased population. This implies increased capacity for production, and again leads to increased prosperity. Surely these are priceless boons worth striving and making sacrifices for.

NATURE OF DISEASE.

Now, it will be quite evident to you by this time that if we are to do anything in the way of preventing disease, it is first essential that we should know something of its *nature* and what produces it. If the steam-engine breaks down, we must first find out what is the matter before we can mend it; if our house leaks, we must first find out the hole before we can stop it. Similarly, we must first know what causes disease before we can prevent it or cure it. Now this is one of the things to which doctors have been specially devoting their attention for many years, and although, as I have already told you, progress has been very slow in the past, yet now we are making very rapid headway, which is due largely to the improved methods of observation which are at our disposal. Among the most important of these are what are called *Microscopes*. You have all seen magnifying glasses, one of which I show you. Well, microscopes are made up of a number of these magnifying glasses so arranged that they make objects appear many hundreds of times bigger than they really are, and make things visible which cannot be seen by the naked eye. During this course of lectures I shall show you objects so small that many thousands could be placed on the head of a pin, yet so perfect are the instruments which we have, that they can, not only be seen, but can be photographed, and made into pictures, some of which are shown you in these lessons. I show you here one of these microscopes, and at every lecture I shall put a few specimens under them so that you may actually see for yourselves some of the things about which I shall tell you.

There are many other methods of investigation which I need not mention to you, and every day by their means we are adding to our knowledge of the causes of disease, so that in the course of time we may hope to know what actually produces the great majority of diseases.

LESSON II.

THE HUMAN BODY.

It is necessary for us, therefore, to study the *causes* of disease, and to enable us to do so satisfactorily, we must first have some understanding of the **structure** and **composition of the human body,** and the **functions** of the different parts, so that we can the better appreciate how disease will affect it. I propose, therefore, at this stage, to describe to you the general structure of the human body, and later on, as we come to study the different sub-divisions of this course of lessons, food, air, and so on, I shall describe to you more in detail the parts of the body, which are specially concerned.

On looking at the body, it is obvious that it divides itself naturally into parts,—

the Head,
the Trunk, and
the Extremities.

The **Head,** which includes the face, is made up chiefly of the brain-case or **cranium,** a rigid bony structure which encloses and protects the brain, the directing centre of the whole organism. Here, too, we find those special organs of sense which are so necessary, the ears, the nose, the eyes and the mouth.

The **Trunk** is divided into two parts, separated from each other by a thin muscular portion called the **diaphragm,** the upper part known as the **Thorax** or chest, and the lower the **Abdomen** or belly. The back of the trunk is supported by a flexible bony pillar, the **Vertebral Column** or backbone.

The **Thorax** is formed by the Vertebral Column at the back, the breastbone in front, and the ribs at the sides. It contains those very important organs connected with the circulation of the blood and with breathing, the Heart, and the Lungs. We have seen that the brain is protected from injury by bone, and we now find a similar arrangement in connection with the heart and lungs, but in this case the bones are movable, as the lungs have to expand and contract during the process of breathing.

The **Abdomen,** or belly, contains the organs connected with the reception and absorption of food, namely the Stomach, the Intestines or Bowels, the Liver and the Pancreas. Other organs are the Spleen, which is concerned with renewing the

blood, and the Kidneys, the purifying or excretory organs. It is supported at the back by the Vertebral Column, while the front wall is soft and composed of muscle, and what is known as fibrous tissue, which permits of its movement during breathing and of expansion when food is taken into the stomach.

Lastly there are the **Extremities,** the upper and lower limbs, and you will observe that though they have both a common plan of structure, they are modified to suit the purposes for which they are intended. The **upper limbs,** specially adapted for grasping things, are lighter in structure, are able to move extensively in every direction, and are provided with long, narrow, flexible fingers.

The **lower limbs,** intended for purposes of support and locomotion, are much stouter and longer, have a much more limited range of movement, and have shorter and less flexible digits.

We thus see that each part of the human body is wonderfully modified in accordance with the different functions which it has to perform.

I have already told you that the body is built up of a number of different parts called **organs,** the brain to do the thinking, the lungs to do the breathing, the stomach to digest the food, the heart to send the blood round the body, the kidneys to get rid of what is not wanted, the bones to support the body, and so on.

Now these different organs are generally divided for purposes of description into groups or **systems,** according to their respective functions, or in other words, the work they have to do.

These systems are :—

1. The **Osseous** or **bony system,** for support.
2. The **Muscular system,** for movement.
3. The **Circulatory** or **blood system.**
4. The **Alimentary** or **Digestive system.**
5. The **Absorptive system.**
6. The **Respiratory** or **breathing system.**
7. The **Excretory** or **purifying system.**
8. The **Integumentary** or **skin system.**
9. The **Nervous system.**

The organs composing these different systems are more or less complicated structures, and are built up of parts called **Tissues**, for example, muscular tissue, fatty tissue, nervous tissue, fibrous tissue, and so on.

I. THE OSSEOUS OR BONY SYSTEM.

This consists of a large number of bones forming a strong framework, known as the **Skeleton,** which we have already seen serves two purposes:

1st. *It acts as a support* to the various soft parts of the body, and

2nd. *It affords protection* to highly important structures and organs.

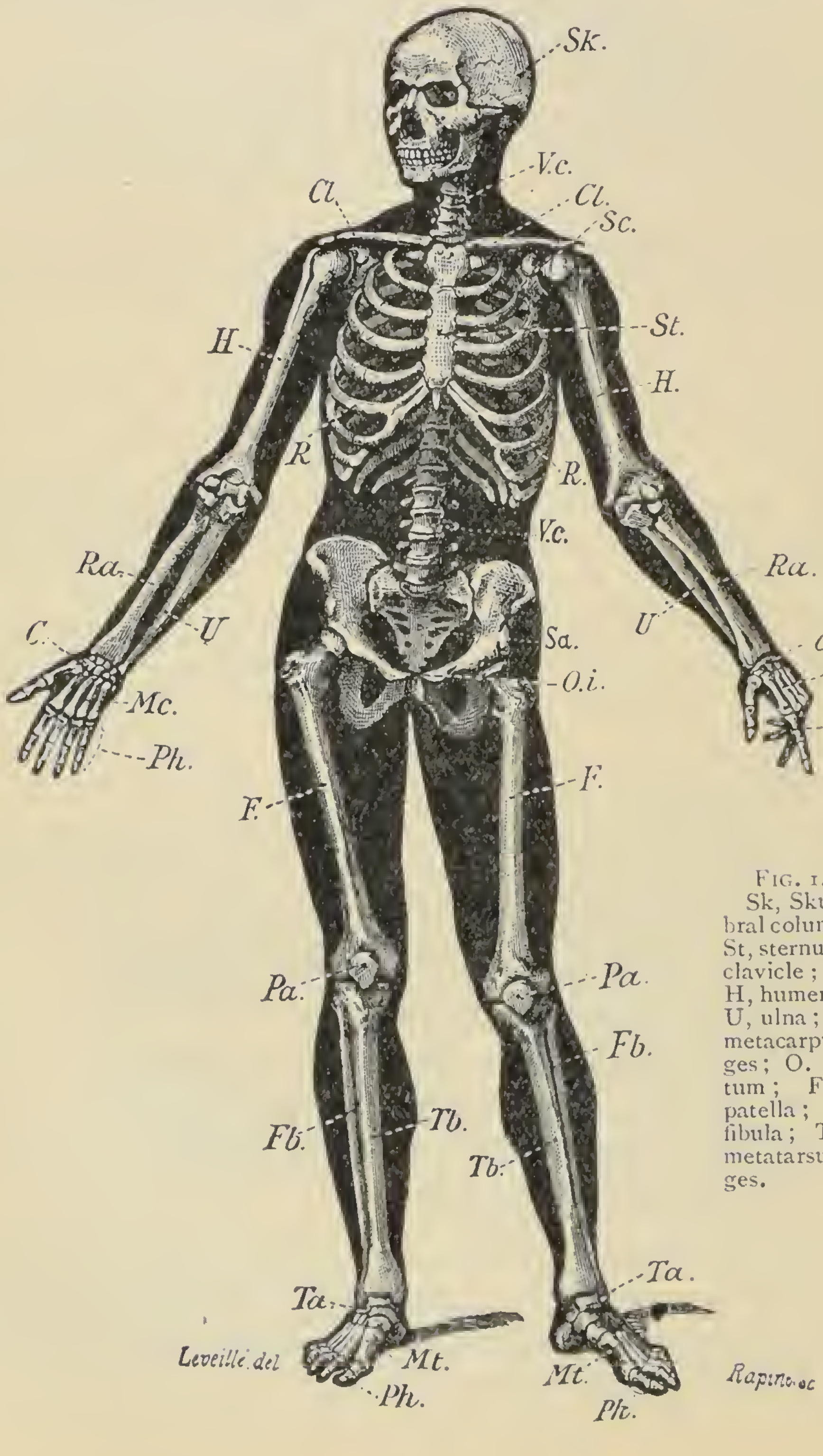

FIG. I.—**Skeleton.** Sk, Skull; V. c., vertebral column; Sa, sacrum; St, sternum; R, ribs; Cl, clavicle; Sc, scapula; H, humerus; Ra, radius; U, ulna; C, carpus; Mc, metacarpus; Ph, phalanges; O. i., os innominatum; F, femur; Pa, patella; Tb, tibia; Fb, fibula; Ta, tarsus; Mt, metatarsus; Ph, phalanges.

The bones are held together at what are called **Joints** by strong fibrous bands known as **Ligaments,** and in some cases are dove-tailed in the same way as a carpenter joins pieces of wood together. In some places a substance called **Cartilage** or gristle, which is more yielding and elastic, is required.

Looking at the general plan of the Skeleton (Fig. 1), it will be seen that it is built round a central pillar, which I have already spoken of as the **Vertebral Column** or backbone. It consists of a large number of separate bones, **Vertebræ**, built one on top of the other like a pile of spools of thread, and between each bone is a small pad of cartilage, to lessen shock. Although the different bones are held firmly together by very strong ligaments, the backbone is flexible, and can be bent backwards, forwards and sideways, and can also be rotated or turned round.

Through the backbone, runs a tube or canal, and in this is contained a bundle of nerve matter called the **Spinal Cord,** from which **Nerves** pass out through a number of small holes at the side, so that the Spinal Cord resembles a bundle of telegraph wires carrying messages from the brain to the different parts of the body. Here, then, you have another example of bones forming a protection for a very important and delicate structure.

At the top of the backbone is the **Skull**, consisting of two parts, the **Cranium**, made up of eight bones joined firmly together so that they cannot move, and forming a box for the brain, and the **Face bones**, also joined firmly together, with the exception of the lower jaw, which is movable. Leading into the skull are several openings, a large one for the Spinal Cord, and smaller ones for the nerves of the ear, eye, and so on.

From some of the vertebræ, a number of **ribs,** twelve, come off to form with the breast bone a kind of box or cage which you have already heard described as the Thorax or Chest. Most of these join to the breastbone by means of cartilage, while two are free, and are called *floating* ribs.

At the lower part of the backbone you see some large bones joined together so as to form a sort of basin, this is called the **Pelvis** and forms a protection for the bladder and other organs, as well as being a support for the lower limbs.

The bones of the **upper** and **lower limbs** are very similar, differing principally in size and strength. There is first of all a flat bone connecting the limb with the trunk, a long rounded bone at the upper part of the limb, two long thin bones, a number of small bones at the wrist and ankle respectively, and the fingers and toes.

Before leaving the bones, I must say a word or two as to their **composition**. You know that a bone is hard, and can be broken with some difficulty. If you take a bone and put it in the fire for some time, you will find that, while it retains

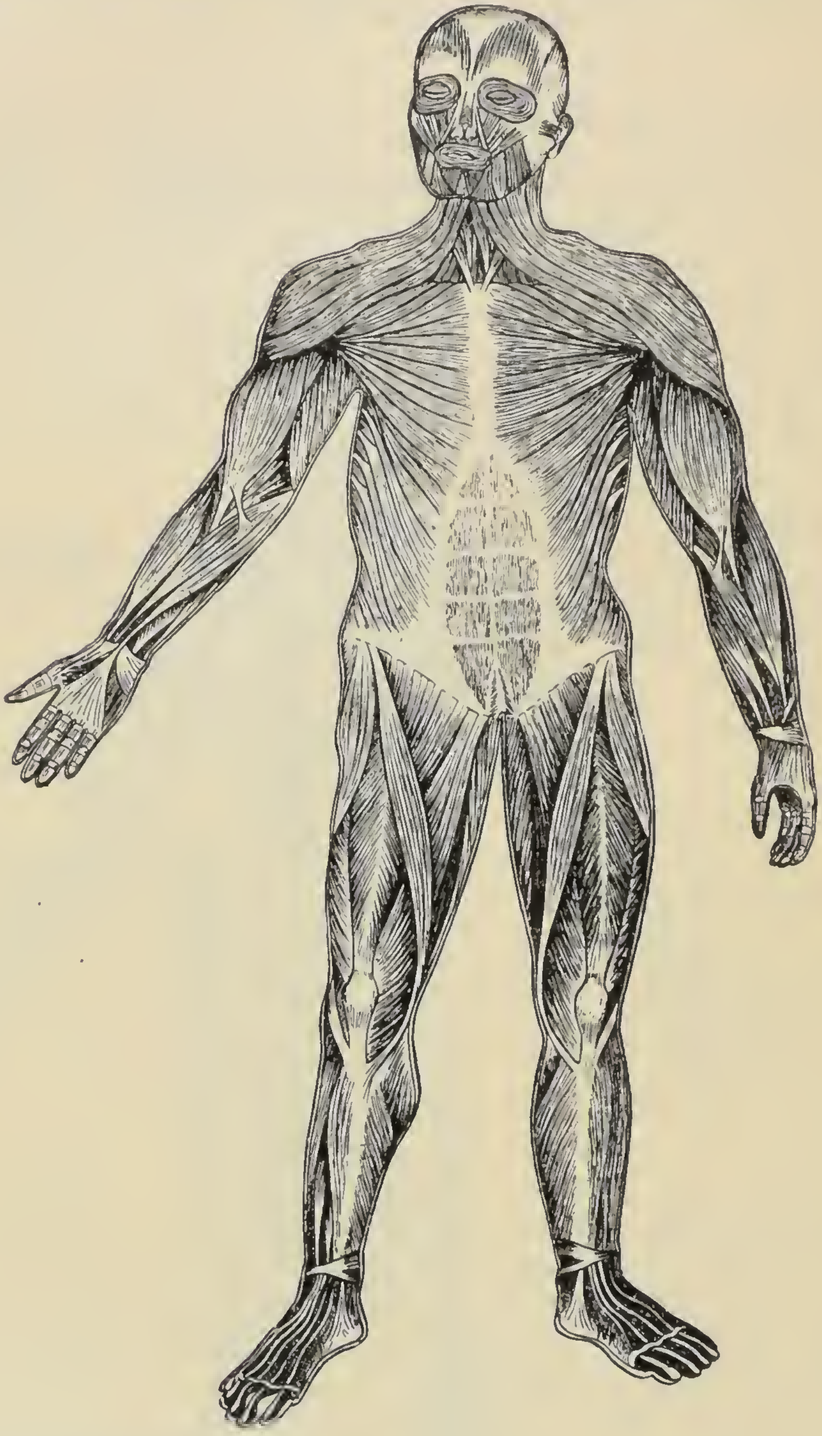

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FIG. 2.—**The Superficial Muscles of the Body, viewed from before.**

its shape, it becomes much more brittle, and can easily be snapped. The fire has evidently destroyed something in it. If now we take another bone, and allow it to soak for some days in weak acid, we find that the hardness has gone out of it, although it again retains its shape, and that it can be bent, but not broken. The acid has taken away what formerly

made it hard. We have learnt, therefore, that bone is made up of two parts, a *mineral*, or *inorganic* part, to which the hardness and rigidity are due, and the *animal*, or *organic* part, from which its toughness and elasticity are derived. The composition of the bones varies according to the time of life, —in children there is more animal matter, and bones bend easily, in elderly people, on the other hand, there is more mineral matter, so that they are more brittle and more likely to break. Sometimes in young children you see the legs bent and deformed. This is due to want of mineral matter, and is often caused by improper food, which we shall consider later on.

2. THE MUSCULAR SYSTEM.

If you remove the skin of an animal, you will find underneath a quantity of red flesh, which in a butcher's shop you would call meat. This is **Muscle,** and it is by means of muscle that we walk, and perform all the movements of which we are capable.

Muscles are divided into **Involuntary** and **Voluntary,** which means that we cannot control the former, while by an effort of will we can use the latter. We see examples of involuntary muscles in the heart, the stomach and bowels, while the muscles of the limbs and trunk are voluntary muscles. (Fig. 2.)

If you examine a muscle carefully you will find that it is made up of a number of small fibres or threads which are all held together by a lining membrane, or sheath. This bundle is attached to bones at both ends, and it is by the contraction of the muscle that movement is effected. As a muscle contracts it becomes shorter and thicker, and thus the two bones are brought closer together. Put your right arm out in front of you, and place you left hand at the upper part. Now bend it slowly at the elbow. You will find that the big muscle in the upper arm bulges and gets thicker—that is the biceps, as it is called, contracting, and moving the forearm at the elbow joint.

Many muscles end in long white cords, called **Tendons.** You will find tendons where the bone to be moved is some distance away, and where it is necessary that too much room should not be taken up by a bulky mass of muscle. For example, it would interfere very much with the delicacy of movement of the hands, if a mass of muscular tissue were situated there, consequently we find that most of the muscles which move the hand and fingers are situated in the forearm, and are connected with the hand by fine tendons, the cords of which you will see at the wrist.

In addition to locomotion, muscular effort is shown in *keeping the body in the erect position* when standing still. A dead body will not stand upright alone, the steady contraction of the living muscles of the legs, the back, and abdomen is required to keep the body erect.

Muscles require constant nourishment, and this is provided by the blood vessels which enter them, and they are also supplied with nerves, which carry messages from the brain, and tell the muscles when to contract and when to relax. If, then, the quality of blood supplied is poor or the quantity insufficient we get wasting of the muscles, and we also find that if muscles are to be kept in good condition they must be used or exercised. A blacksmith's arm, for example, gets very strong because it is constantly used, similarly, those who have to walk long distances develop very strong muscles in the legs.

We see, then, that in order to keep the muscles, which form 41 per cent. of the body weight, in health, *regular exercise*, and a *supply of good suitable nourishment* in sufficient quantity, is required.

3. THE CIRCULATORY SYSTEM.

This consists of the **Heart**, a number of tubes called **Arteries** and **Veins,** and a fluid which circulates in them, the **Blood.**

By means of the **Circulation** food is carried to all the different parts of the body, and the waste products are taken up and carried to the proper organs for disposal. In order that the food should reach easily every part of the body, it is clear that the blood must be constantly moving, and that the tubes through which the blood moves must be so arranged and divided as to permit of this.

Now we find that this is provided for in a very thorough manner. The **Heart**, which is the organ which sends the blood through the body, is like a small pump and is always squeezing itself together, and every time it does so, it empties itself, and forces the blood through the blood vessels. These are like a lot of little pipes, those nearest the heart are big, those furthest away, are very small. All of you have seen the water pipes being laid down in the streets. Well, the big tank on Tower Hill is the heart, which sends the water all through the town, the water is like the blood and the pipes are the blood vessels. Near the tank you will have noticed that the pipes are large, farther away they become smaller, and in the stand-pipes and houses they are quite small.

The **Heart**, which is shown closed in Fig. 3, and opened in Fig. 4, is a hollow, muscular organ, and is situated in the chest, towards the left side. If you put your right hand inside your jacket on the left side, you will be able to feel what is called the *apex*, or point, beating between the fifth and sixth ribs. The heart is of a conical

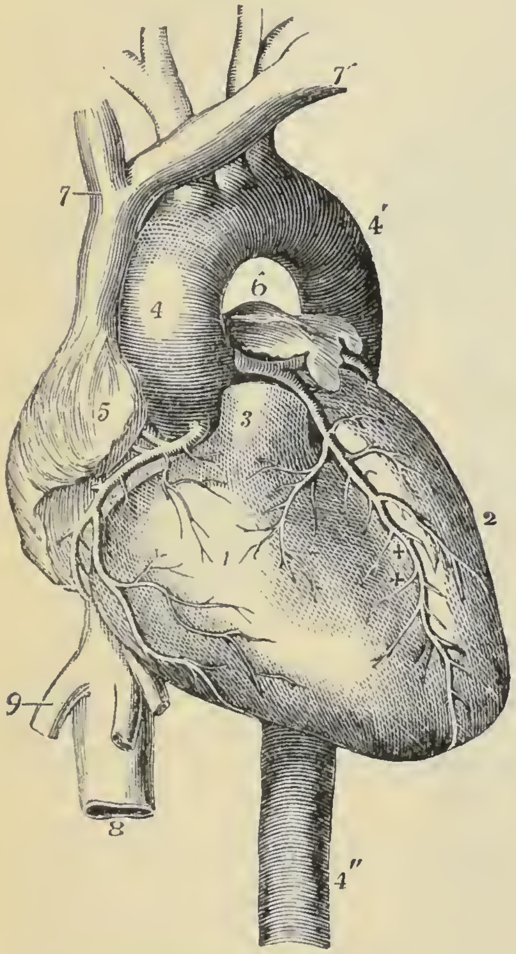

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Fig. 3.—**The Human Heart and its Vessels, viewed from before.**

1 right ventricle; 2, left ventricle; 3, root of the pulmonary artery cut short; 4, 4′, and 4″, the aorta; 5, right auricle; 6, left auricle; 7, veins which unite to form the vena cava superior; 8, inferior vena cava; 9, hepatic vein; +, coronary arteries.

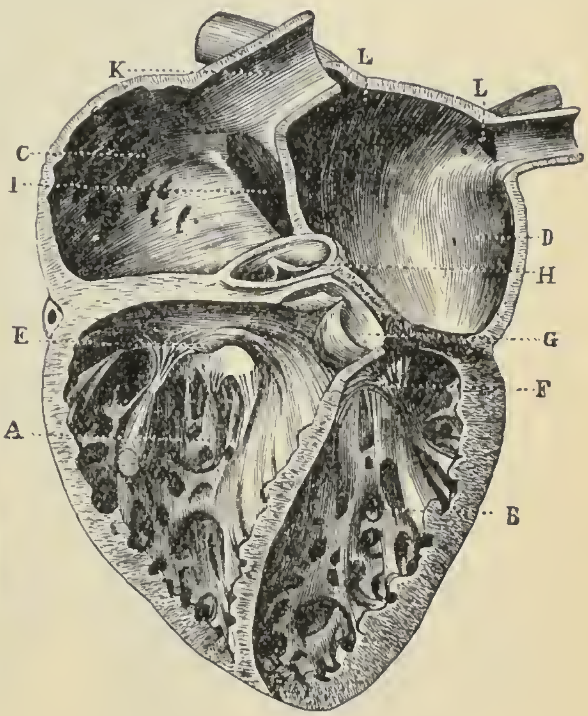

Fig. 4.—**The Heart opened from the front to show its Chambers.**

A and B, right and left ventricles; C and D, right and left auricles; E, tricuspid, and F, mitral valves; G, pulmonary artery; H, aorta; I, orifice of inferior vena cava; K, superior vena cava; L, L, orifices of pulmonary veins; M, termination of longitudinal septum; P, papillary muscle.

shape, the apex being downward and to the left, and the broad part upwards and to the right, and from the latter part you will see that the large blood-vessels come off. It is contained in a smooth shiny bag, the **Pericardium**, in which there is a small amount of a clear fluid, so that, as the heart opens and shuts, it can work easily, just as oil makes an engine work smoothly.

Inside, the heart is divided into two by a partition, the right and left sides, the former receiving the impure blood

which comes from the body, and the latter the purified blood coming from the lungs. Each side is again sub-divided into an upper part, called the **Auricle,** and a lower, the **Ventricle.** The following diagram will give you a better idea of this :—

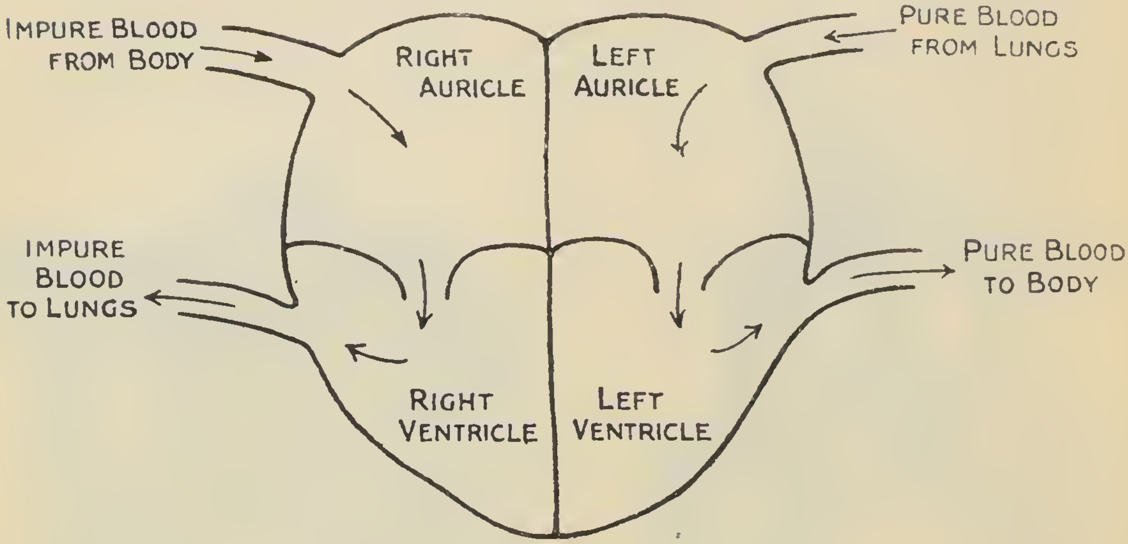

FIG. 5.—**Diagram of Heart.**

In the partitions between the auricles and ventricles, there are openings which allow blood to flow from one to the other, and these are guarded by **valves,** which prevent the blood flowing backwards.

The **Right Auricle** is a thin walled cavity and has two large veins (I shall tell you what these are directly), by means of which the impure blood from the head and body enters the heart. The valve between it and the right ventricle consists of three thin flaps, and is called the **Tricuspid Valve.**

The **Right Ventricle** has thicker walls than the Auricle, and opening out of it is a large vessel called the **Pulmonary Artery,** which carries impure blood to the lungs. The opening is guarded by three valves like small pockets, which are called **Semi-lunar valves.**

The **Left Auricle** has also thicker walls, and receives the purified blood from the lungs by four veins called the **Pulmonary Veins**. The opening into the left ventricle is provided with two flaps, and is called the **bicuspid** or **Mitral Valve.**

The **Left Ventricle** is the thickest walled and the strongest cavity of the heart, because it has to force the blood through the whole of the body, and out of it opens the **Aorta,** the largest blood-vessel in the body. This, too, is provided with semi-lunar valves.

The **Blood-vessels** are of three kinds: Arteries, which carry the blood from the heart; Veins, which carry it to the

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FIG. 6.—**General View of the Circulatory System, showing the arrangement of the Heart and the larger Blood-vessels.**

H, the heart. The arrows indicate the direction of the blood-stream.

heart; and Capillaries, which are very small vessels connecting the two. (Fig. 6.)

The **Arteries** are thick walled tubes, and when they are cut they do not close up. They are elastic and contractile,

and are thus able to dilate when blood is poured into them. If you place one of your fingers at the outer part of your wrist, you will find an artery beating, that is expanding and contracting. The arteries contain red blood, and when one is cut the blood comes from it in jets. They generally occupy protected positions so that they cannot be easily injured.

The arteries eventually end in **Capillaries**, which are very minute thin walled vessels, forming a network in all the tissues of the body. Through the thin walls, a constant interchange takes place between the tissues and the blood; oxygen and nourishing material are given out, while carbonic acid gas and impurities are taken up. As a result of this we find that in the capillaries the blood changes from bright red to purple.

The **Veins,** which receive the blood from the capillaries, and carry it back to the heart, are thin walled vessels which collapse when cut. The blood which they contain is purple, and is seen to flow in a continuous stream when the vein is

FIG. 7.—Red Corpuscles.

opened. Most of them contain pocket valves, to prevent the blood flowing backwards. The veins lie on or near the surface for the most part, and if you will tie a piece of string, not too tightly, on your arm, you will be able to see for yourselves a number of these distended blood-vessels or veins.

The **Blood** appears to the naked eye as a bright red fluid, but if we spread a thin layer of it out and examine it under a strong microscope, we see that it is really composed of a clear fluid called the **Plasma,** and a number of solid bodies floating in it, which are known as *blood cells* or *blood corpuscles.*

There are two kinds of these, red and white, and although the proportion varies, as a rule there are about 500 red corpuscles to one white.

Red Corpuscles are rounded bodies like coins or biscuits. They are not quite flat, but are hollowed out on both sides, as is shown in Fig. 7.

Outside the body they have a tendency to run into heaps like piles of coins.

When seen singly they are yellowish, and it is only when there are a large number together that we get the red colour.

The colour is due to a substance called **hæmoglobin,** which is very important, for it is the carrier of the oxygen from the lungs to the rest of the body. After the hæmoglobin has given up its oxygen in the body it changes colour, and then we have the purple colour of the blood in the veins.

In a healthy person the number of red cells in a drop of blood remains about the same, and we can tell by counting them whether a person is well or ill. After a bad attack of fever, for example, the number becomes much smaller, and if you look inside the patient's eyelid you will notice that it is pale instead of being red, as it ought to be.

The **White Corpuscles** vary very much in size and possess the power of changing their shape, and by this means

Fig. 8.—White Corpuscles, showing change of shape.

crawl about in the blood. They act as scavengers, and, as you will find later, are able to eat up foreign bodies which get into the blood.

When blood is taken out of the body it is quite fluid, but in a short time it becomes solid, forming a **Clot.** This consists of a mass of fine threads called **Fibrin,** among which lie the blood cells, and a pale yellow fluid called **Serum.**

The blood then is composed as follows :—

Plasma { Serum.
Fibrin-forming substances.
Fibrin Ferment.

Red Corpuscles.
White Corpuscles.
Oxygen, chiefly in combination with hæmoglobin.
Carbonic acid gas, chiefly in solution in the plasma.
Nitrogen, small amount in the plasma.

We are now in a position to study the **Circulation of the blood,** and in Figure 9, I show you a diagrammatic representation of this. Let us begin with the veins. The impure blood is pouring along them, collected from the limbs, the liver, the stomach, the head and other parts, and finally reaches the right auricle through two large veins, the superior and inferior venæ cavæ. The right auricle then contracts, and forces the blood into the right ventricle. In its turn, this

contracts, the tricuspid valves close, and the blood is pumped into the Pulmonary Artery, and so into the right and left lungs. It may be pointed out here the pulmonary arteries are the only *arteries* in the body which contain *impure* blood. In the lungs it becomes purified, giving up the carbonic acid and other impurities it has collected from the body, and taking up fresh oxygen from the air.

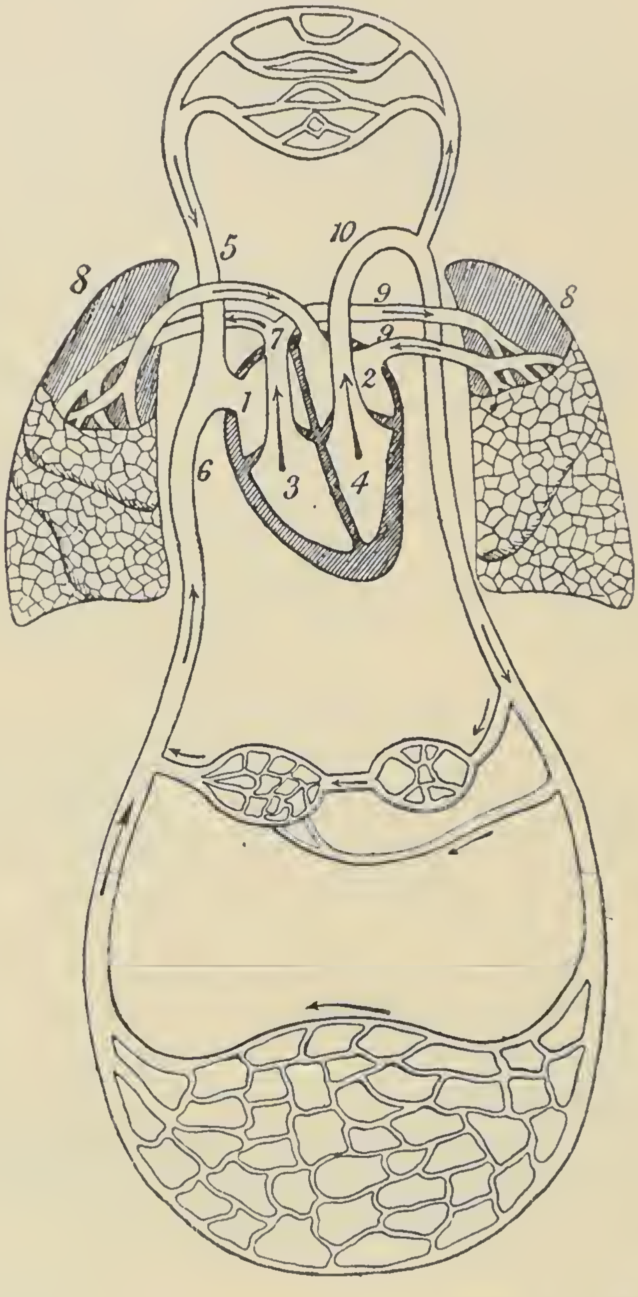

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FIG. 9.—**Diagram illustrating the Circulation.**

1, right auricle; 2, left auricle; 3, right ventricle; 4, left ventricle; 5, vena cava superior; 6, vena cava inferior; 7, pulmonary arteries; 8, lungs; 9, pulmonary veins; 10, aorta.

From the lungs the blood returns to the heart, entering the left auricle by the Pulmonary Veins, which we must note are the only *veins* containing *pure* blood. It then leaves the

left auricle and enters the left ventricle by the bicuspid valve, and finally leaves the heart by the aorta to be distributed to the different parts of the body. From the upper part of the aorta, large blood vessels go off to supply the head and upper limbs, from the descending part, branches supply the stomach, bowels, liver, spleen, kidneys, &c., and at last it divides into two large branches, which supply blood to the lower limbs. From the small arteries, the blood passes into the capillaries, then into the veins, finally returning to the heart by the two large veins, to begin its circular journey once more.

We see then that there are two distinct circulations in the body, the **Pulmonary Circulation,** by which the blood passes from the right side to the left, becoming purified in the vessels of the lungs, and the **Systemic Circulation,** in which the blood leaves the left ventricle, goes through the body and returns to the right auricle. We can now understand how, if any cause of disease obtains admission to any part of the circulation, it is readily distributed to every part of the body.

LESSON III.

THE HUMAN BODY—(*continued.*)

4. THE ALIMENTARY OR DIGESTIVE SYSTEM, AND

5. THE ABSORPTIVE SYSTEM.

These we shall consider in detail when we come to study the subject of food, and I shall briefly indicate here the outlines only.

Food, after having been chewed, is received into the **Stomach,** and passes through the **Bowels,** what is left being finally excreted by the rectum. During its passage it undergoes a process known as *digestion*, that is to say, the hard lumps disappear, it undergoes certain changes, becomes fluid, and is then ready for *absorption*. It next enters a series of small vessels called **Lymphatics,** and eventually reaches the blood in the veins, by which it is distributed to the whole body. The **Liver** and the **Pancreas** are two other important organs in the abdomen which are intimately connected with digestion.

6. THE RESPIRATORY OR BREATHING SYSTEM.

This, too, will be more conveniently studied later on in connection with the air. You have already learned that the organs concerned in respiration are the **Lungs** situated at each side of the chest, and that the blood becomes purified by passing through them. Later on, we shall study carefully what happens to the air, as it is breathed in and out, but even at this early stage, you are beginning to understand how very readily impurities may obtain admission to the body, and to realise how necessary it is that we should know something of the human frame, if we are to apply satisfactorily the principles of sanitation.

7. THE EXCRETORY OR PURIFYING SYSTEM.

You are all aware as a matter of everyday experience, that in all trades, and in the operations of our daily domestic life, it is impossible to use everything up,—there are certain things which are unnecessary and useless, and which must be got rid of. For example, in a furnace or fire, whether it be coal or wood, a great part burns away, leaving a useless residue, the ashes. When you eat a plantain, you take off the skin and throw it away; when you prepare foofoo from cassava, a harmful juice is first squeezed out; when palm kernels are used for making oil, the outside skin or husk has first to be removed. These are what are called **waste products.** And so it is with the human body. When we take in a supply of food, part of it is useless and has to be got rid of; and when we work either by using our muscles or our brains, parts of the body are used up, and we have waste products. Now if these waste products were allowed to collect in the human body, they would do harm; they must therefore be removed and the process by which this is done is known as **Excretion.**

We have already come across examples of this. We have seen that what is not consumed in the Alimentary Canal is got rid of by the rectum and that the lungs also remove impurities from the blood. These then are **Organs of Excretion.** The liver, which I have told you is connected with digestion, is another organ of excretion. But there are two organs which I have not yet mentioned, and which are very important, for if they are removed, or become so diseased that

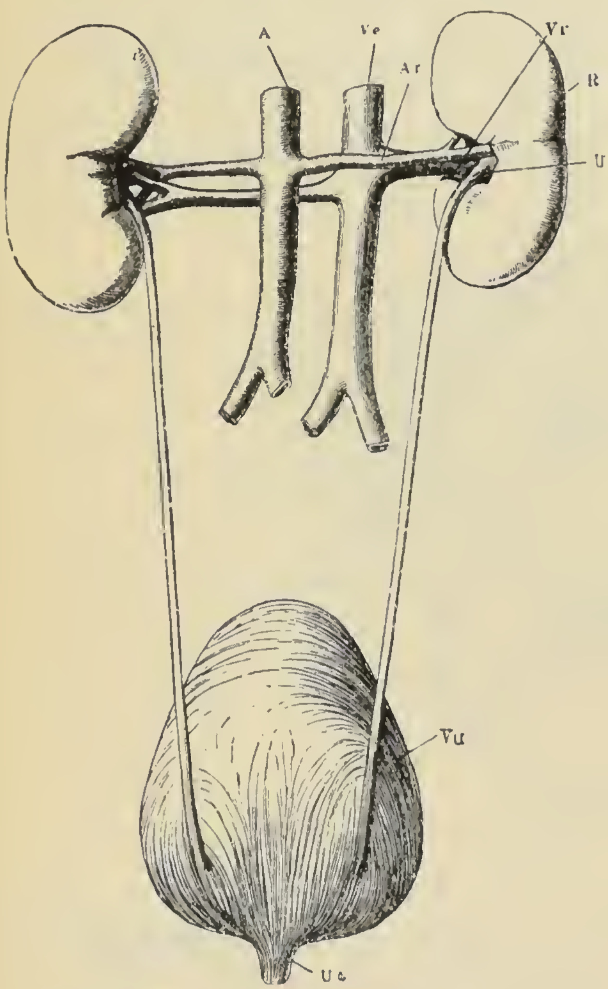

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FIG. 10.—**The Kidneys, Bladder, and their Vessels. Viewed from behind.**

R, right kidney; U, ureter; A, aorta; Ar, right renal artery; Ve, vena cava inferior; Vr, right renal vein; Vu, bladder; Ua, commencement of urethra.

they cannot work, death inevitably takes place,—I refer to the **Kidneys**.

They are two in number, and are situated at each side of the back bone in the abdomen. Their shape is well shown in the accompanying diagram (Fig. 10). The part where there is a depression is called the **hilus**, and here the blood vessels, nerves, and the ureter enter and pass out. The **ureter** is a long narrow pipe leading down to the **bladder**, to which is carried **the urine,** the fluid secreted by the kidney. If we cut the kidney across (Fig. 11), the substance is seen to be formed of two parts, the outer dark brown, the **cortex,** and the inner paler and finely striped, the **medulla.**

The open part from which the ureter passes is called the **pelvis**.

On examining the substance with a strong miscroscope, it is seen to be composed of a number of very fine pipes or **tubules**, which are surrounded by innumerable capillaries.

The function or work of the kidney is to *secrete urine from the blood*. The waste products in the blood are carried into the small capillaries round the tubules, and there extracted,

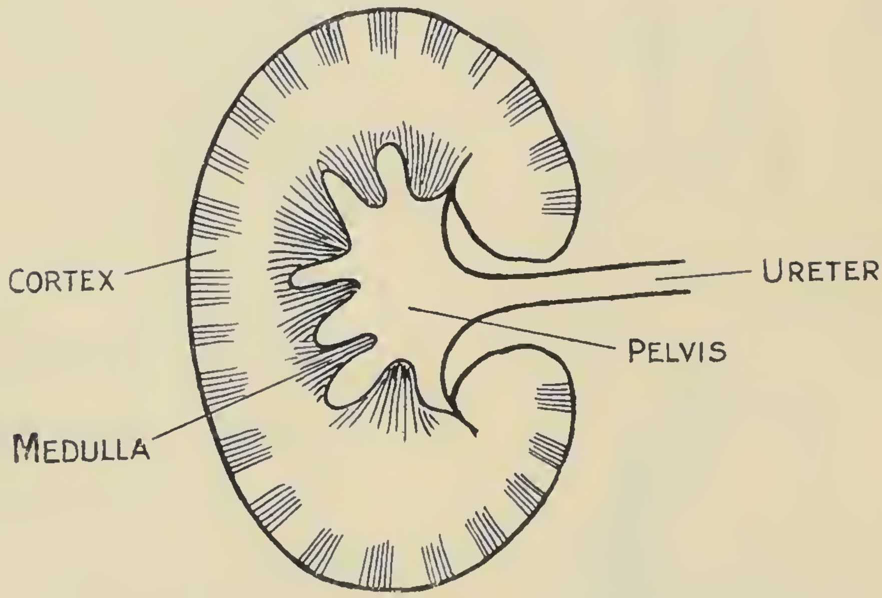

Fig. 11.—**Diagram of Kidney.**

and drop by drop the urine trickles into the pelvis of the kidney, then into the ureter and finally into the **Bladder**, an oval bag with strong muscular walls, which enables its contents to be discharged when necessary.

The **Urine** is a pale clear yellow fluid, consisting principally of *water* in which is contained *salt*, and other *mineral substances*, and an organic substance called *Urea*. Usually about 40 to 50 ozs. is passed during the twenty-four hours, but in this hot country, where the skin acts freely, the quantity is much less.

Lastly, the skin, which we shall consider next, is also an excreting organ.

We thus see that the principal excretory organs of the body are—

(*a*) **the alimentary canal.**
(*b*) **the lungs.**
(*c*) **the kidneys** and
(*d*) **the skin.**

THE INTEGUMENTARY SYSTEM.

This consists of the skin and its different parts, the hair, the nails, the sweat glands, &c.

The **Skin** is formed of two layers, the outer one being called the **epidermis**, or **cuticle**, and the inner the **dermis**, or **true skin**.

The **Epidermis** (Fig. 12) varies in thickness in different parts of the body, and becomes thickest in parts which are most exposed to use. For example, you know how thick and

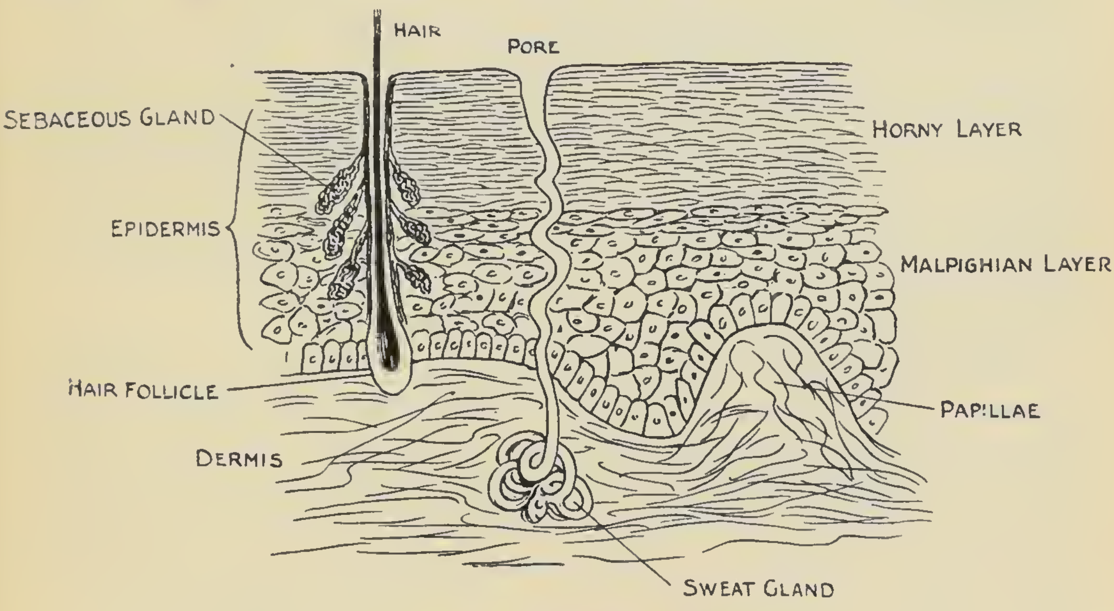

FIG. 12.—**Diagram of Skin.**

hard the soles of the feet become in people who are accustomed to go about barefoot.

The outer part of the epidermis consists of flat horny scales, and it is this part which rises when a blister is formed. The lower portion of the epidermis is called the **Malpighian** layer and it is here that the colouring matter or pigment, which gives different skins their colour, is to be found.

The epidermis is the *protective layer* of the skin, it will not let liquids pass through, and it does not contain either blood vessels or nerves. If it is cut, however, liquids, poisons,

and what are known as germs, can penetrate into the deeper layers and thus into the body generally.

The **Dermis**, or true skin, consists of fibrous tissues containing a large number of blood-vessels and nerves, and it is thrown up into a number of folds, called **papillæ.** These are best developed where the sense of touch is most delicate, as for example in the hand, and you can see that there a number of external ridges are formed.

Underneath the dermis and connecting it with the muscles, is a quantity of loose connective tissue, in which fat is to be found.

If you will look at the back of your hand you will see a number of tiny holes. These are called pores, and are the openings of the **Sweat Glands**. If a thin section or cutting of the skin is examined under the microscope, a twisted tube or pipe is seen running down into the dermis, where it becomes coiled up and forms a sweat gland. (Fig. 12.)

In this the sweat is constantly being manufactured, finding its way to the surface of the skin by the small canals, and giving it that moist feeling which it ought to have. This is known as **insensible perspiration**. But when the weather is hot, or we work hard, we can see the sweat gathering in little beads on our skin, and occasionally running down in streams. This is called **sensible perspiration** because it can be seen. As the sweat comes out, it is constantly evaporating and drying up, and as evaporation causes loss of heat, the skin is most important in keeping the temperature of the body at the proper level.

On the other hand, when we suffer from fever, the sweat glands do not act, and the skin becomes hot and dry ; and many of you have experienced the feeling of relief which comes over you, after you have had a hot drink of tea-bush and the skin begins to act. The skin is then getting rid of some of the poisonous matters in the blood which cause the fever, and is thus acting as an organ of excretion.

Sweat is composed principally of *water* with *common salt*, some other *mineral salts*, and a little *carbonic acid*.

There are other glands in the skin called **Sebaceous Glands.** They produce an oily substance, and serve to keep the skin and hairs soft.

Hairs are another form of epidermis, and grow out of small pits called follicles (Fig. 12). Several sebaceous glands open into the hair-follicle.

Nails also are outgrowths of the horny epidermis.

We have thus learned that the skin has several important functions or uses.

First of all, it *serves as a protection* to the parts underneath, supporting them and preventing foreign matters from getting in, and we see how necessary it is, therefore, to protect all cuts, or places where the epidermis has got rubbed off.

Second, owing to the arrangements of nerves in it, it acts as an *organ of touch.*

Third, it is an *excretory organ*, getting rid of water and waste products by the sweat glands ; and,

Fourth, it serves to *equalize the temperature* of the body. If we are to be in good health, the body must always remain about the same temperatnre. Now, you very rarely find the temperature going so low in this country as to be fatal, but in some very cold climates a person may be frozen to death, if he is not properly protected. On the other hand if the temperature gets too high, as it does sometimes in " fever," the individual is certain to die, if it is not brought down quickly.

You have been told that one method of keeping the temperature level is by the *evaporation of the perspiration*, and this is also assisted by the network of capillaries which is found in the dermis or true skin. These are able to enlarge and get smaller, and when they get large, more blood comes to the surface of the body, and then more heat can be given off, and the body cools down. The opposite takes place when the vessels contract.

It is clear then, that the care of the skin is a very important part of what is called *personal hygiene*, of which I shall speak to you later. If we allow the sweat and sebaceous glands to get closed up by dirt, waste matter is kept in the blood, and more work is thrown on the kidneys. The cake of dirt which forms on the surface of the skin, affords a good soil for what are called germs to grow in, and disease is produced.

Cleanliness, therefore, is essential if the skin, and consequently the body generally, are to be kept in a healthy condition.

9. THE NERVOUS SYSTEM.

This is the great *directing* system. By it the movements of the body and the functions of its organs are controlled. It is the seat of intelligence and will, the centre which governs our daily life and actions, and there are recorded the impressions which we gather of the external world by means of the special organs of sense, sight, hearing, touch, and others.

It consists of the **Brain,** the **Spinal Cord,** and of various **Nerves.**

The **Brain** is a very complicated structure contained in the cavity of the skull.

From the base, the **Spinal Cord** runs down inside the backbone, giving off nerves as it proceeds. It is, to a large extent, though not entirely, a *conducting medium*, that is to say, it carries messages from the brain to different parts of the body, and from the body to the brain.

After leaving the spinal cord, the brain messages reach the parts of the body by what are called **Nerves.** They are of different kinds. Those going to muscles are called **motor** nerves, those connected with the skin, **sensory** nerves, because by their means we have, what is known as sensation or feeling. Then, there are special nerves, which do special work, the nerve leading from the eye by which we see, from the ear by which we hear, the tongue by which we taste, and the nose by which we smell. And all these nerves have special nerve endings adapted to the particular work which each has to perform.

Lastly, there is what is known as the **sympathetic** nervous system—two thin cords with little swellings on them, situated at each side of the backbone. It supplies nerves to and controls the internal organs and involuntary muscles.

Such then is a brief description of the structure and functions of the human body, and we are now in a position to proceed with our study of the *causation of disease*, to learn how it affects the human being, and to study its practical application in the prevention of disease.

LESSON IV.

CAUSES OF DISEASE.—GERMS.

The causes of disease may be roughly grouped into two classes, namely, *internal*, those arising from within the body, and *external*, those arising from outside influences. The former are also called the *non-preventable* and the latter the *preventable* diseases.

Among the **internal causes** one of the most important is *heredity*, that is to say the constitution which we get from our fathers and mothers, and our grandfathers and grandmothers. These are diseases arising out of what I have called our constitution, diseases such as gout, rheumatism, stomach troubles, and so on. Many of them can be modified and sometimes prevented by attention to our special weakness, by care as to food, clothing, exposure, and other details of what we may call *personal hygiene*.

But the great majority of diseases arise from **external** influences, such as cold, excessive heat, indiscretions in living, all of which I shall deal briefly with later on. Among these external causes, however, there is a very important group, to which I now wish to draw your attention, namely, those in which *the disease is produced by the introduction into the body of living bodies from without*, which are able under certain conditions to grow and flourish. These bodies are called "*parasites*."

PARASITES.

A **Parasite** is *a body which lives and grows on or at the expense of another body*, which is called the "host" Sometimes it lives simply on the host without hurting it; at other times it lives at its expense, absorbing its proper nourishment or producing poisonous substances which are harmful.

I show you here a specimen of what is known as African Mistletoe, which can be found in many parts of the West Coast of Africa. It grows on a tree, and you will find that part of the tree gradually withers up and dies. Evidently this parasite takes up the nourishment which ought to go to sustain the tree. In other cases, you will see many plants, ferns, etc., growing on trees, which appear to do no harm,

These are examples of harmful and harmless **vegetable** parasites.

Then there are **animal** parasites. An example of this is the "jigger," which you all know, a little animal which gets under the toe-nails and into other parts of the body, and forms a little bag which must be very carefully taken out, otherwise it produces painful sores. Other examples are ordinary fleas and bugs, which are not dangerous but are very uncomfortable.

But while some of the parasites which affect the human body do little harm beyond causing a certain amount of discomfort, many of them, both vegetable and animal, are responsible for the most terrible diseases which afflict mankind, diseases which yearly cause a most serious loss of life. It is necessary for us, then, to study carefully these parasites, to learn under what conditions they grow outside the human body, how they obtain admission, how they act inside it, and what steps we must take to prevent their growth and to destroy them.

And first of all I shall direct your attention to a very important group of parasites.

GERMS.

Germs are very small bodies, so small that they are invisible singly to the naked eye, and require very great magnifying powers to be seen. They are everywhere round us; at the present moment you are breathing hundreds in and hundreds out, your hands are covered with them, and they are lying thickly on the floor. Every morsel of food you eat and every drop of water you drink under ordinary circumstances contains plenty of them. I say under ordinary circunstances, for as I shall tell you later, it is possible by taking certain precautions to get rid of them.

I have told you that germs are so small as to be invisible, and yet I am sure that there is not a person in this room who has not seen germs many times. Let me try to explain this to you. If you take a tiny grain of salt and put it in a spoon, you can hardly see it because it is so small, but if you fill the spoon you can see the salt at once, though it is just a collection of the same small grains. And so it is with germs, though singly they are invisible, yet when there are many thousands of them crowded or growing together, they form a mass which is visible to the naked eye. I will tell you of one or two places where I am sure that you have seen germs. If you put away your boots in the rainy season for a day or two without wiping them, you have often noticed white spots

growing on them. That is one kind of germ. Or if you leave your clothes without drying them, you find spots of what you call *mould* on them. These again are germs. Or, once more, if a cheese is cut and kept for some time, little yellow, white or blue spots grow on it. All these are examples of germs, and you have already learned one fact with reference to them, and that is, that damp tends to make germs grow.

VARIETIES OF GERMS.

Germs are of different kinds, and fortunately for us, all of them do not produce disease. A great many are harmless, some are actually beneficial, while some of them produce the most deadly diseases which we know, such as plague, cholera, and consumption, which cause an enormous loss of life. It is against these that sanitation teaches us to direct our efforts.

These different kinds of germs are to be distinguished from each other in different ways, just as vegetables can be distinguished by size, shape, and so on.

I have told you that germs are very small, so small that it is very difficult to convey to you an exact idea as to their *size*. Some of them are so minute that twenty thousand of them placed in a row side by side would only measure one inch, while it would take four hundred millions to cover a square inch. There are about 40,000 people living in Freetown, so that we would require to have 10,000 Freetowns to give us the same number of people as the number of germs which would go into a square inch. Some germs are larger than this and some smaller.

Then again they differ in *shape*, and it is according to shape that we divide them up into groups.

The first group are *round*, and are known as **Micrococci** (see Fig. 13 A).

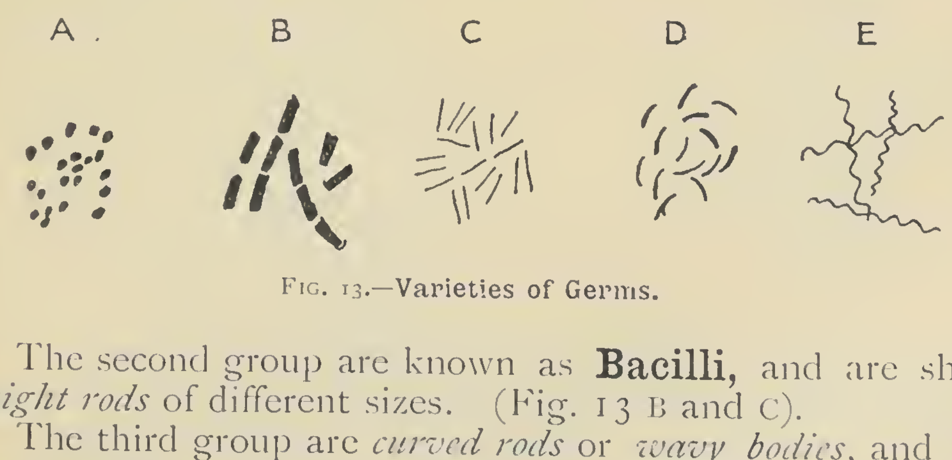

FIG. 13.—Varieties of Germs.

The second group are known as **Bacilli,** and are short *straight rods* of different sizes. (Fig. 13 B and C).

The third group are *curved rods* or *wavy bodies*, and are called **Spirilla**. (Fig. 13 D and E).

In addition to these three forms, there are two other classes, **yeasts** (Fig. 14) and **moulds** (Fig. 15). The latter

are long threads with tufts on the end, and we can see them growing on cheese and old bread.

The *colour* of germs, too, is sometimes distinctive, for when they grow in masses, they may be yellow or blue or red or grey or white.

We see, then, that we can distinguish germs from each other by size, by shape and sometimes by colour.

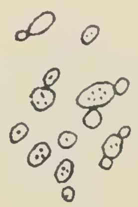

FIG. 14.—**Yeast Cells.**

FIG. 15.—**Moulds.**

CONDITIONS OF GROWTH.

Soil.

But there are other differences, and one of them is the **conditions under which they grow.** Different kinds of germs require different conditions. To go back to vegetables once more, you know that to grow properly they require different soils. For example, tomatoes require very rich soil with plenty of manure, while carrots grow best in a sandy soil. Cocoanut trees grow best in sandy soils near salt water, those which grow palm-nuts grow well far away from the sea. And so it is with germs. Some grow best in decaying vegetable matter, some in the earth, some in the body, and so on, and of all the soils which are fitted for the growth of germs, *anything that has had life* is the most suitable. For example, germs grow freely in dead animals, and the smell which a body gets after death, is due to germs causing the body to rot or putrefy. Dirt of all kinds is suitable for the growth of germs, dead leaves, vegetable refuse of all descriptions, remains of food, and so on. Liquid and solid excreta are particularly dangerous. Thus we see that if germs are to be diminished, *dirt is to be got rid of at once.*

Water.

But the soil is not all. Vegetables require a certain amount of **water**. If they get none, they die; if they get too much, they do not flourish. So with germs. If they are dried, they stop growing, and drying enough will sometimes kill them altogether. On the other hand, if they get the proper amount of moisture—and they can stand a great deal —they flourish very luxuriantly.

Temperature.

Again, vegetables require the **temperature** to be right. In England, for example, if a touch of frost comes when the plants are young, it kills them, and, on the other hand, you know that in the heat of the dry season, all the grass and plants dry up. Germs are affected in the same way. Cold prevents them from growing, though it is very difficult to kill them in this way, while the proper warm temperature will make them grow very quickly. A very high temperature, on the other hand, will kill them altogether, and this is one of the ways in which we kill and get rid of the germs of infectious disease.

Oxygen.

Further, most germs require a certain amount of **air,** or rather a gas called **oxygen**, which is contained in the air.

Light.

Lastly, **light** has a very considerable influence on the growth of germs. It has been found by very careful experiments, that when germs are exposed to sunshine, they gradually lose their vitality, and are incapable of growth, while darkness or a subdued light favours their multiplication.

We see, then, that Germs require five things for their proper growth and multiplication, namely :—

1. **A suitable soil;**
2. **A proper degree of moisture;**
3. **The right degree of heat;**
4. **A supply of oxygen;** and
5. **The presence or absence of Light**;

and we can interfere with the growth of germs by altering any one or all of them.

METHODS OF INCREASE.

Now, how do these germs grow and increase in number? If one of the round or rod-like bodies gets into the blood, how does it grow sufficiently to produce disease? For it is only when there is a large number that disease is produced. There are two principal methods.

The first one is very simple, and is known as **fission** or **division** (Fig. 16). It is just this, that each germ divides

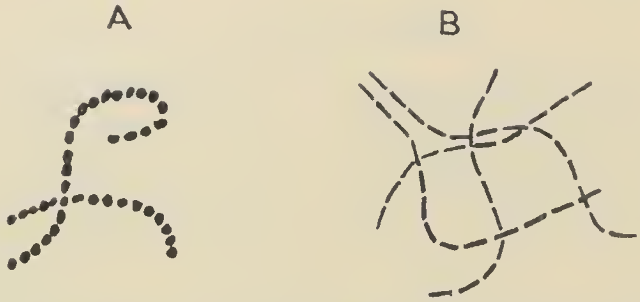

FIG. 16.—Micrococci (A), and Bacilli (B) showing fission.

into two, these two into two more, and so on. Some of these germs grow so rapidly that they divide every half hour. If, then, you start with one, at the end of half an hour you have two, at the end of an hour four, at the end of an hour and a half eight, and at the end of two hours, sixteen, and if you will take the trouble to work it out, you will find that at the end of twelve hours there will be over eight millions.

The second method is by means of little seeds, or as they are called **spores**. In the inside of each germ—and this is generally seen in the rod-like bodies—a small clear spot forms, and when this is ripe the outer skin bursts, the seeds get outside, and can grow into new germs.

FIG. 17.—Germs showing spore formation.

I show you here a specimen of the germ which causes a very deadly disease in animals (Fig. 17), and can also be produced in man, showing not only the growth by division but spore formation. There is also another kind of spore formation, where the germs are like bottles or pears (Fig 17),

with a spore in the thick end. This is the germ which causes the disease called tetanus or lock-jaw.

Now these spores are very important, for this reason, that *they are much more difficult to kill than the full-grown germs* themselves, and are, consequently, very dangerous. It is by means of these spores that a great many infectious diseases are spread. They require very intense heat to kill them; in fact, boiling for a short time will sometimes do them no harm, and they may live for years hidden in the folds of clothing, or in the corners of a room, ready to grow and do damage as soon as they find a suitable soil and opportunity.

METHODS OF INTRODUCTION OF GERMS.

We now come to consider **how germs get into the body.**

First of all, they may be eaten with **food.** Food which has been in contact with a person suffering from a disease caused by germs, should never be eaten by another person, as he may contract the disease in this way, and all food should therefore be carefully preserved from such contamination.

Then, secondly, we may get germs into our body by means of **drinking water,** and it is in this way that a great many diseases are spread. Typhoid is one of these, and is generally caused by drinking water contaminated by sewage, and when I come to talk of the disposal of excreta, I shall show how very poisonous and dangerous many of the wells in this town are. Fortunately, we have now a plentiful supply of good pure water, and this danger is not so great as it used to be, or as it is in some places on the coast. Still, we cannot be too careful about keeping the water we drink pure, and seeing that it is kept in clean vessels and carefully protected.

Thirdly, germs may get into the body from the **air** by **breathing** them into the lungs, whence they may get into the blood. Consumption is caused in this way, and inflammation of the lungs or pneumonia also.

The lungs are the organs by which we get fresh air for the use of our bodies, so you can readily understand how easily germs can get in if they are floating about in the air.

Fourthly, germs may get in **through the skin.** If there is a cut or even a slight scratch, very serious diseases may be produced, and if there is a big sore, which is very common here, you can realise how germs may get into the blood in this way. There is no doubt that this is the way in which that dangerous disease called tetanus or lockjaw,

which is comparatively common here, gets into the blood. Hydrophobia, a terrible disease, fortunately unknown in this country, is introduced into the blood by the bite of a mad dog.

Germs may also be introduced into the blood by the bites of insects, such as mosquitoes, fleas, etc. If the insects feed on a person or beast whose blood is swarming with germs, they will carry it away with them and infect the next person they bite. It is believed that in this way fleas carry plague from rats to human beings.

To recapitulate, disease germs can get into the body by (*a*) **Food,** (*b*) **Water,** (*c*) **Air,** and (*d*) the **Skin,** and prevention must be directed against each of these channels of entrance.

METHODS OF FIGHTING DISEASE GERMS.

Having arrived at this stage, I can almost hear some of you saying, if germs are all around us, if we are apt to take them in our food and drink, whenever we breathe, and even through our skin, how can we possibly escape? Is there any good taking precautions? Had not we better let matters take their course, and if we have to die, we must die.

Fortunately, not only have we means of fighting these disease germs, but Nature itself fights them for us.

(*a*) Outside the Body.

First of all, if germs do not get suitable food they tend to die out, and we can see that they do not get suitable food by *keeping our houses and yards scrupulously clean*, and by seeing that all dirt and decaying matter is promptly removed. One of the greatest dangers of this town is the practice of storing refuse in cesspits. These, as I shall show you later, not only contaminate the soil all round, but pollute the air of the houses, and you can see that if any disease germ such as cholera got into them, you would simply be providing a storehouse where it could be kept ready for use. They are especially dangerous if a disease such as cholera or typhoid were to get a footing in the town.

Germs, too, *tend to kill one another;* the beneficial ones in the soil prey upon and destroy the disease germs.

Then, *sunshine and light* are hurtful to the growth of germs. Never be afraid of letting the sun get into your houses, and keep the trees in your yards trimmed so as to let the sunlight in. It is in damp, dark, badly ventilated places that germs flourish.

Again, *personal cleanliness* is a great thing. If we keep our bodies and our clothes clean, we prevent germs getting into our skins, and thus not only prevent them from getting into our blood, but avoid getting the skin diseases which are so common here, and most of which are caused by germs. *Plenty of soap and water is one of the best preventives of disease* which we have.

We have, therefore, already learnt some valuable lessons in sanitation—first, that *cleanliness* is essential; and, second, that *light*, *sunshine*, *free ventilation*, and *freedom from damp* are great preventives of the growth of disease germs.

But suppose a disease produced by germs has been introduced into a locality, how are we to prevent its spread? And here again we are able to assist Nature.

Disinfectants, ETC.

You have already learned that germs grow best when the soil is suitable. Now we can alter the soil, by adding to it substances which are harmful to germs, and which will interfere with their growth. Such substances are known as disinfectants or antiseptics, and I must now explain to you what they are.

Disinfectants *are substances capable of killing germs and thus preventing the spread of infectious disease.* I shall give you examples of these immediately.

Antiseptics are *substances which prevent putrefaction.* When a piece of meat or fish goes bad, the process is called putrefaction, and is caused by germs. Now a strong mixture of ordinary salt prevents germs from growing, so that if we soak meat or fish in salt we prevent it from becoming rotten. Salt, then, is an antiseptic.

Deodorants, on the other hand, are substances which *take away a bad smell.* Charcoal does this. It is important to remember, however, that taking away a bad smell does not necessarily mean taking away the danger; the disease-producing germ may still be there, for the deodorant does not necessarily kill it.

Heat is one of the best disinfectants. Clothes, for example, may be disinfected by boiling them, or better still by heating them with steam under pressure. But you must remember that some spores are very difficult to kill, and consequently infected clothing must be boiled for a long time.

Then, again, as I shall tell you when we come to study water, *boiling* is the best way of killing the germs in it.

A good chemical disinfectant is *Carbolic Acid*, but I wish to give you a word of warning. I often get applications for carbolic acid from people who say that there is a bad smell on the premises. They cheerfully sprinkle a few drops about, they get the smell of the carbolic and they are perfectly happy. Now all that they have done is to substitute one smell for another. To kill germs with carbolic acid, it requires to be very strong and very concentrated, and to come in actual contact with the germs themselves. The vapour or smell of carbolic acid is not nearly strong enough to kill germs. If a place is dangerous it wants thorough cleaning from top to bottom. It should be *washed* out with some disinfectant. If, therefore, you find a place has a bad smell, do not content yourself with sprinkling a few drops of carbolic or some other disinfectant, *find out what is causing the smell* and then remove it, and cleanse the place thoroughly.

For *disinfecting the air* one of the best things is burning *Sulphur*. When sulphur is burned it gives off a gas which has the power of killing germs. Here, again, there must be plenty of it, all the doors and windows must be carefully closed, and the smoke from the burning sulphur should be so strong that a person cannot breathe in it. Then the room should be left closed with the gas in it for one or two hours, so that it gets into all the corners.

There are many other things which have the power of killing germs, but it is not necessary for me to tell you all of these. Let me once more impress upon you that *cleanliness*, *sunlight*, and *good ventilation are the best disinfectants* you can have, and they are within the reach of the poorest people in Freetown.

(*b*).—**Inside the body.**

But in spite of all our precautions, in spite of cleanliness and care, a disease germ has gained admission into our blood, what happens then?

I have told you how quickly these germs grow; how in the course of twelve hours one germ will have grown to over 8,000,000. Well, even here nature provides certain safeguards. If the body is in a good state of health, if every organ is working properly, the germ does not find the suitable soil, and it dies before it can begin to produce others.

Then there are the white cells in the blood, of which I spoke to you (Fig. 8). The largest ones are called **Phagocytes**, and

as soon as germs get into the body, they make for them at once, gradually absorb them into their inside, and digest them there. Sometimes, however, the germs which get into the body are so numerous, or are so strong, or perhaps the body is not in good health, the Phagocytes are consequently not very well, and the germs begin to grow, and the disease is produced. When this happens it is the duty of the doctor to try and get rid of these germs, and to keep the patient alive while he is doing so, which is often a very difficult matter. These germ diseases have been so carefully studied, that in nearly all of them we know how long the germs will take to grow before they show any signs, how many days they will remain in the body, and about what time the person will begin to change if he is going to get better. In some cases **medicines** will help to kill the germs, but in a great many, all we can do is to aim at keeping the person alive until the germs run their appointed course.

Toxins and Antitoxins.

Now there are one or two curious points about the life of these germs in the body which are very interesting, and which you should know, especially as it again illustrates how Nature herself tends to provide a cure.

As the germs grow in the body, they produce certain poisonous substances, just as in certain manufactures hurtful and evil-smelling matters are produced. These substances are called "**Toxins,**" and they are the cause of the symptoms in disease—the headache, the vomiting, the hot dry skin, and so on. But now comes a curious thing. Not only do they produce toxins, but, after a certain time, they begin to produce what is called an "**Anti-toxin**"; and this substance has not only the power of counteracting the effect of the toxin, but, in time, of actually preventing the growth of the germs, and actually killing them. If we could count on this always happening the treatment of fevers would be an easy matter; but sometimes the number of germs which is introduced is so great, and the toxins are produced in such large quantities and so rapidly, that the patient dies before the anti-toxin has time to be manufactured. This happens in plague, which, as you know, is a very fatal disease.

Immunity.

In some diseases doctors have been able, by long and careful experiment, to make these anti-toxins from the germs themselves, and in some cases we are able to use them to

prevent people from getting certain diseases, and in others to cure them when they have actually got it. This has been done in hydrophobia and in diphtheria. Although we have not yet been able to find the germ of small-pox, yet there is no doubt that the lymph which we use for vaccination causes an anti-toxin to grow in the body which prevents people from getting small-pox. And this brings me to another interesting fact in connection with germs and anti-toxins, and that is what is called "**Immunity.**" When a person gets an attack of small-pox you all know that he is not likely to get another, and that is true of a number of diseases, such as scarlet-fever, measles, etc. What happens is that the presence of the germ in the blood produces a toxin, and some change in the body results which prevents that particular germ growing in the body in the future. It is then said that the person is *immune* to that particular disease.

The length of this immunity varies in different diseases. In cases of small-pox it generally lasts all one's life, in other diseases it does not last so long. Now in some diseases, we have been able to prepare a substance which will produce an artificial immunity. Thus in plague what is called a "**Serum**" has been discovered, which, when injected under the skin of a person, will prevent him from getting the disease. There is also a serum for typhoid fever, and at the present time medical men are experimenting hard to obtain other serums, and in time there is little doubt that we may hope to obtain substances which will prevent or cure all the infectious fevers.

HOW DISEASE GERMS ARE GROWN ARTIFICIALLY.

But perhaps some of you are wondering how we manage to study these disease germs, how we can catch them and grow them, and ascertain what they are like. It is impossible for me to tell you all the different methods, but I will show you the one which is most commonly used. This is what is called a test tube, and in this is placed a small quantity of a specially prepared clear yellow jelly. The jelly has been heated and cooled, and heated and cooled several times, until all the germs and all the spores have been killed. Then it is put in these test tubes, and a plug of cotton-wool, which has also been heated for a long time, is quickly put in. The object of this plug of cotton-wool is to prevent any germs which may be in the air falling into the test tube. Then when we wish to study a germ we get some of it from the sick person, as pure as possible, and putting it on the end of a long needle, we carefully but quickly remove the cotton-wool cork, and push

the needle into the jelly, where the germ begins to grow, and as germs grow in different ways, we are able to tell them from one another in this way. Fig. 18 shows you a picture of a germ growing in jelly; and you will see that it is quite

FIG. 18.—Bacillus of Anthrax grown in test tube.

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characteristic. Germs are sometimes grown on potatoes, on bread crumbs, and in other ways, which I need not go into here, but in all cases the materials have to be specially prepared, or what we call "sterilised," in order to kill the germs which may already be in them.

LESSON V.

SPECIAL DISEASE GERMS.

I have thus given you very briefly a general description of germs and their mode of action, and now we proceed to study some of the Special Disease Germs.

ABSCESSES AND BOILS.

First of all, I would tell you about **Abscesses, Boils,** and **Sores,** or what doctors call **Ulcers.**

You all know what a **Boil** is. A hard swelling comes on your body or in the armpit; it feels very hot, and causes you a great deal of pain. It gradually gets bigger and bigger, gets soft in the middle, and then bursts, and a lot of white matter comes out.

Fig. 19.—Streptococcus pyogenes (germ of abscess) forming chains.

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An **Abscess** is much the same, only it is rather larger, and sometimes it will not burst itself, and requires to be opened with a knife.

These are caused by one of the round germs called "micrococci." It obtains entrance through the skin by means of a cut or even the tiniest scratch, and begins to grow in the connective tissue, where the irritation of the poison causes a collection of white matter or "pus" to form. In Fig. 19, you see this germ growing and forming long chains.

ULCERS.

Sores or **Ulcers** may be formed by an abscess bursting and not healing up, or a person may cut or wound himself,

and then he lets a little dirt get in, and instead of healing up, the germs begin to grow, and gradually eat up the skin, and sometimes go deeper and eat away the flesh, and even the bone. You have all seen people going about this town with huge sores on their feet, and when their sores have lasted a long time they twist the feet or the legs out of shape, and they become deformed. This is all the result of *dirt* getting into a wound, and then afterwards, instead of keeping them scrupulously clean, people wrap them up in dirty rags, and allow more filth to get in, and they get bigger and bigger until they form those filthy, bad-smelling sores, which we see so much of at the Colonial Hospital ; and if you examine a little of the matter from one of these sores under the microscope you will find thousands of germs of different kinds.

Now these germs grow in all kinds of decaying matter, and especially in dead animals, and they get into the blood by means of the skin, or by cutting or pricking yourself with a dirty knife or a dirty pin or needle. The slightest scratch or prick, sometimes so small that you can hardly see it, is quite enough to allow one of these germs to get into the body.

I believe that germs get into the skin out here from the clothes, and that the clothes get them from the ground, owing to the practice of drying clothes on the ground after washing them, instead of hanging them up in the air to dry on ropes, as is usually done in other places. Washerwomen here are not careful to choose a clean place, but put the clothes anywhere, even on bare earth sometimes ; and as there is always a great deal of decaying vegetable matter about it is easy to understand how they can get germs on to them. In this country, where it is very hot, and people perspire greatly, they are apt to get prickly heat, or some irritability of the skin, and scratch themselves to stop the itching, so that the surface of the skin is broken and germs are easily introduced. I believe it is in this way, too, that many of the skin diseases which, as I have told you, are caused by germs, are caught. If you could persuade the washerwomen of this place to *hang up the clothes* on ropes—and there are plenty of trees to stretch ropes between—I am sure you would be doing a great deal to lessen the number of those boils and skin diseases.

Now, from what I have told you, it is quite evident that if you have a cut or a prick the first thing to do is to get it *quite clean.* You should wash it well with *clean* water, and, if you can get it, *water which has been boiled* and allowed to cool is the best to use, for all the germs have been killed by

the boiling, and you do not run the risk of putting any more in. Sometimes, if it is a small prick or a small cut, it is a good thing to suck it, and to make it bleed, for that washes the germ out. Afterwards wrap it up in a *clean* rag, and you must be sure that it *is* perfectly clean. After you have used a rag you should never use it again, but should carefully burn it.

Then the same thing must be done with big sores. The first thing to do is to get them *clean*. At the hospital we sometimes get a big, dirty, bad-smelling sore, and the first thing we do is to scrape off all the filth and wash the surface, and then we use some antiseptic lotion (you remember what antiseptics are) ; next we put clean cloths or dressings on it, and in a few days it begins to get clean, turn bright-red, and a fresh skin begins to grow at the side. Sometimes when a patient comes in with a sore, I find that it is covered with chopped up leaves, or sometimes with a mixture containing cow or horse dung. I need hardly tell you how dangerous this is, because these things are simply splendid places for germs to grow in, and they are swarming with them.

SEPTICÆMIA.

Occasionally, some of these germs get into the blood, and instead of forming a boil or an abscess, they spread all through the body, and cause a kind of blood poisoning, or what we call **Septicæmia,** and boils and abscesses form all over the body. This is a very serious disease. One of my medical officers some little time ago pricked himself when he was making an examination of a dead body, and he suffered from this form of blood poisoning, and has still got the marks of the abscesses on him.

You see, therefore, how in all these cases perfect *cleanliness* must be exercised, and how easy it is, by doing this, to prevent the large sores, which I have mentioned, forming.

PNEUMONIA.

The next disease is one which is very common here, especially in the Harmattan season, namely, **Inflammation of the Lungs,** or **Pneumonia.** It is a disease characterised by great pain in the side, high fever and cough, and is caused by this germ getting into the lungs and growing there. Here, people get very hot in the night, and go outside without anything on, when there is perhaps a strong Harmattan blowing, and get a chill. Now, although the chill itself will

not cause pneumonia, yet if this germ happens to be in your lungs, the chill, by sending all the blood inside from the skin to the lungs, prevents them from working properly, and then the germ finds its opportunity and begins to grow. It is impossible to prevent this germ from getting into our lungs, as it is blown about in the air, and this is especially the case during the Harmattan season, when everything is very dry and dusty, but we can prevent it from growing by avoiding chills, and by keeping ourselves in a good state of health.

TETANUS.

I come next to a disease which I have already mentioned incidentally, namely, **Tetanus** or **Lockjaw,** the germ of which is shown you in Fig. 20. This is a disease which affects the muscular system; the muscles tie themselves up, and become quite stiff and hard, so that the person cannot bend them. This happens in the muscles of the neck and back, so that the person's head is drawn back, and his back is bent like a bow; and sometimes this is so great that the sick person will be bent with only his head and feet touching the ground, like an arch. The name *lockjaw* is given to it, because one of the symptoms is, that if the person tries to take anything by the mouth, the muscles of the jaw shut up tight, and he is unable to open his mouth, and consequently to chew or eat anything. That is why, when we get cases of this kind, we have to feed them with milk and gruel and eggs beaten up, which can be poured in at the side of the mouth. Later on, the muscles of the chest are affected and get stiff, so that the person cannot breathe properly, and dies.

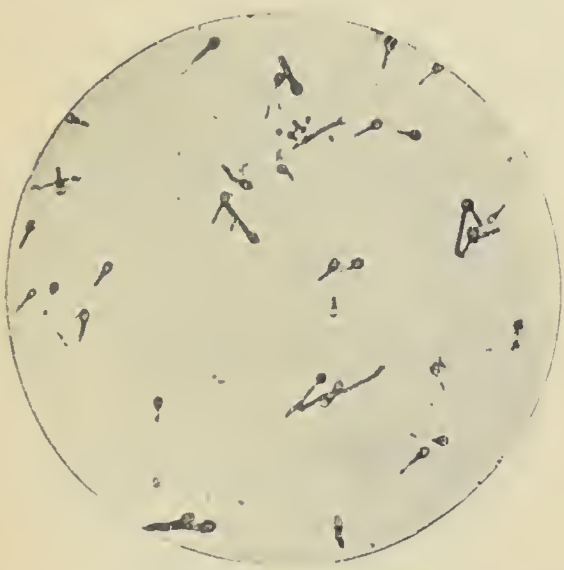

FIG. 20.—Tetanus germs.

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Now this is another germ which gets in *through the skin.* There used to be a common idea that a cut between the thumb and forefinger was sure to be followed by lockjaw, and I remember very well, when I was a boy, how anxious I used

to be for a few days when I cut myself there. But there is no more danger in a cut there, than there is anywhere else, provided the germ does not get in. The reason that that idea existed is, that this is a place where you are very likely to cut yourself, or, if you fall down, you put your hand out on to the ground to save yourself, and you scratch or cut yourself there and get the germ into your blood. But by far the most common way that people appear to get the germ into the system here is by the sores and cuts on the feet. In many of the cases which come into the hospital, there are large sores on the legs.

The place where this germ grows best is *the earth*, and especially in places where there is a rich soil, or where there is decaying matter which is contaminated with horse or cow dung. I once had a monkey at the Colonial Hospital which was tied up to a tree near the ground by a cord round its waist. The skin got slightly rubbed off on the waist where the cord went round, and one day the Dispenser came to me and said, "Your monkey has got tetanus." And sure enough it had, and died shortly afterwards. There is no doubt that it got it from the soil of the hospital compound, which has probably a lot of these germs in it, owing to the number of cases of lockjaw which we get.

If, then, a person gets this germ into a sore it begins to grow there, and it produces a *Toxin*, which goes all through the body and causes the symptoms which I have just described to you.

This affords another example of what I have just been telling you—(and I shall have to go on repeating it)—the necessity for *perfect cleanliness* in connection with cuts and sores, for in addition to abscesses and boils, you may acquire this much more dangerous disease. If you fall down and scratch your hand, you should always wash all the earth very carefully off it. Sores on the feet and legs should be carefully protected by clean cloths so that the germ will not get into them, and, lastly, all rubbish should be always cleared away from your yards, especially refuse from cows or horses.

There is another way that this germ can get into the body, and that is by *being blown about*. As this germ grows in the earth you can understand how, during the dry season, it is bound to be carried in the dust which we see flying in clouds along the streets, and if there is an open sore it is likely to get into it. We have such a long dry season here—three or four months without a drop of rain—that it is impossible to prevent dust altogether, but a great deal can be done by *watering the streets properly*, and I hope that this matter will be taken up seriously. As you will learn later,

not only is there a danger of these germs—such as the pneumonia and the tetanus germ—getting into the blood, but the eggs of some animal parasites are distributed in this way.

CONSUMPTION.

The next disease which we shall consider is that terrible disease known as **Consumption,** or, as medical men call it, **Tuberculosis.** This disease is one which appears to be more common in temperate climates, but we have a good deal of it here, and no doubt all of you have known some one who has had it. In England and Wales over 40,000 people die of it every year, and medical men are working hard to diminish the mortality ; and there is no doubt that, since we have known the cause, our efforts have been much more successful. It is very often more severe and more rapid in hot countries. It is a disease which most commonly affects the breathing apparatus, the lungs, but sometimes attacks other parts —such as the bowels— and then we have consumption of the bowels, consumption of the kidneys, and so on.

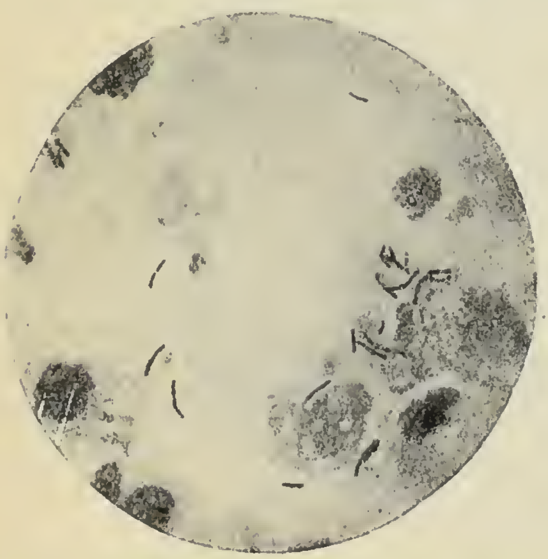

FIG. 21.—**Bacillus of Tubercule in sputum.**
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When a person's lungs are affected with consumption he has a cough, spits a good deal, and gradually wastes away. If you could look inside his chest and examine his lungs, you would first see a number of little white or grey spots ; then these get bigger and bigger until they break down, and big holes in the lungs are formed, just like large sores. Nature tries to get rid of the broken down matter, and so the person coughs and spits. Sometimes, when these holes are being formed, there is a blood vessel in the middle which bursts, and then the person spits blood. Now if you take one of these white spots and prepare it in a special way, you will see under the microscope, a number of little germs, which are called Tubercle Bacilli, and are the cause of the disease (Fig. 21). If you examine what a man spits up in the same way, you find these germs in it again, and nowadays,

when a man comes to a doctor complaining of cough and spitting, we examine the spittle or "*Sputum*," and we can then tell whether the sickness is consumption or not.

Consumption is a disease which can be breathed in, and can be communicated from one person to another. It is now coming more and more to be looked upon as an infectious disease, and if we could put all those people suffering from consumption apart—just as we do small-pox—there is no doubt that in time it would be stamped out, for it appears to grow chiefly in human beings and in cows. In fact, it is believed that human beings get consumption sometimes from drinking the milk of consumptive cows.

Now, what are the conditions under which consumption seems to flourish? First of all, *dampness of the soil* appears to be favourable to it; and, secondly, *bad ventilation* and *overcrowding*.

It is evident, then, that consumption can be diminished by *rendering the soil drier*, and this can only be done by proper drainage. Every yard should have a properly made drain running out of it, and each street should have a good drain at each side. This place is all sloping, and although—owing to the large rainfall—we cannot make it quite dry during the wet season, we could at least make it much drier than it is. I shall again allude to this question of surface drainage in connection with the prevention of Malaria. Then, *overcrowding of houses* must be avoided, and *windows should be left open* at night. If windows are shut closely, and there are a number of persons sleeping in the room, the air gets breathed over and over again, and finally becomes very foul; and if there is any person there who has got consumption, he breathes the germs out, and the healthy persons breathe them in and acquire the disease.

Formerly we used to be very frightened of allowing consumptive patients to get a chill, but now we make them sleep with the windows wide open and make them stay outside all day in the depth of winter, and we find that that is one of the best ways of treating the disease, and that a great many recover in this way.

Then every one suffering from consumption should have a *proper spitting cup*, so that all the sputum can be disinfected and burnt; and when outside he should spit into a cloth, which can be burnt, or carry a special spitting bottle. In the Hospital we put some disinfectant in the spitting cup to kill the germ. Such persons should never be allowed to spit on the ground, because the sputum dries and the germ gets blown about in the air and some person may become infected, and, for this reason, in some parts of the world, people are

punished severely if they are found spitting in the street, or in a railway carriage.

LEPROSY.

Leprosy is another disease which can be communicated from one person to another, and the germ resembles that of consumption in some ways. I have already told you of the very strict laws which the Jews had in connection with leprosy. Leprosy is spread nearly all over the world, but is much more common in some parts than in others. In China and India it is very common, in the West Indies, and also at the Cape. In Great Britain and Europe leprosy is now almost unknown, but it was very common in the Middle

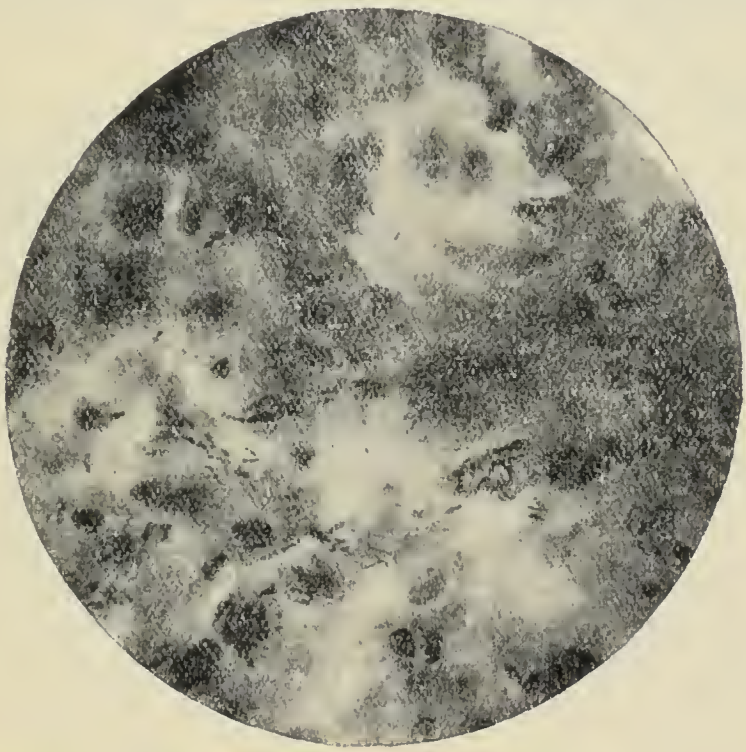

FIG. 22.—**Bacillus of Leprosy.**
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Ages, so much so, that very strict measures were taken as regards segregation and isolation, and this gradually had the effect of making it disappear, and the last British leper died in 1798—that is over one hundred years ago. So that again we have another example of what sanitary measures will do in eradicating a disease.

Leprosy is not common in Freetown, but there are one or two in the Male Incurable Asylum, and as soon as I find a case I send him out there. In some parts of the Protectorate I understand that the disease is much more common than it is here, and we are always apt to get one or two cases from there.

I need not describe the disease to you, because it is a disease which takes a great many shapes; but you know that in some cases it is very disfiguring, that it causes lumps to form on the face and body, that bad sores form which may eat away the bones, and the limbs get twisted and sometimes parts drop off. The leprosy germ is rod-shaped, and therefore belongs to the bacilli. (Fig. 22.) It can be found in the skin and in the lumps I mentioned, as well as in the discharge from the sores, and it is probably in this way that it is transmitted from one person to another.

We do not know how the germ grows outside the body, or if it does grow outside, or how it gets into the body. Some people believe that it grows on dried fish, and that it gets into the body in this way, but it is by no means proved. What is certain is that one person can give it to another, so that the best thing we can do is to *isolate the leper*; and if ever you hear of a leper you should advise that he should be isolated, and you should take steps to give information about him. Every one should take care *not to wear a leper's clothes*, or *drink out of the same cup* that a leper has been drinking out of, and if he has to touch a leper, should be *very careful about washing* himself thoroughly afterwards.

CHOLERA.

The next disease which I shall describe to you is **Cholera.** I have already told you that this is a very deadly disease, and that in Europe it has killed thousands of people; but that in England, although the disease has been introduced several times, yet, owing to the improved sanitation, the pure water, and the precautions that have been taken, it has never spread.

The principal symptom of this disease is violent diarrhœa, which is so bad sometimes that the person collapses and dies in a few hours. It is caused by one of those germs called spirilla, and I here show you a specimen which has been taken from the stools of a patient. (Fig. 23.)

Now, the principal way in which the germ of cholera gets into the blood is by means of *water*, and sometimes by means of *dirty cooking vessels*, or *dirty plates* or mugs. I show you here a specimen of water containing the comma bacillus, and though this one may not actually give you cholera, yet all such water should be looked upon as dangerous, and should be carefully avoided. If a water supply once becomes contaminated with this cholera germ, you can understand how easily it will spread to a number of

people, and you will realise the *necessity of keeping the source of our water supply protected from contamination.* We have now a very good supply, but we have had to be very careful to take it from a place where there are no houses, and we must see that they are not allowed to be built anywhere near, otherwise our water may get polluted.

In this town the great danger of cholera spreading would be the *cesspits* which are all over the town. In some parts of the town we have a cesspit, which is often simply a hole dug in the ground, within a few feet of a well, and if you examine the water in the well you can easily find signs of sewage contamination, and yet people have been drinking the water from these wells for years, and wondering why they get dysentery, diarrhœa, and so on. Well, if the germ of cholera gets into one of these cesspits near a well, it would grow downwards into the well, and would then be drunk by a great many people, and there would be a bad outbreak. Now that we have a good water supply which is pure, you will see how necessary it is for us *to close all those wells* which can be polluted in this way.

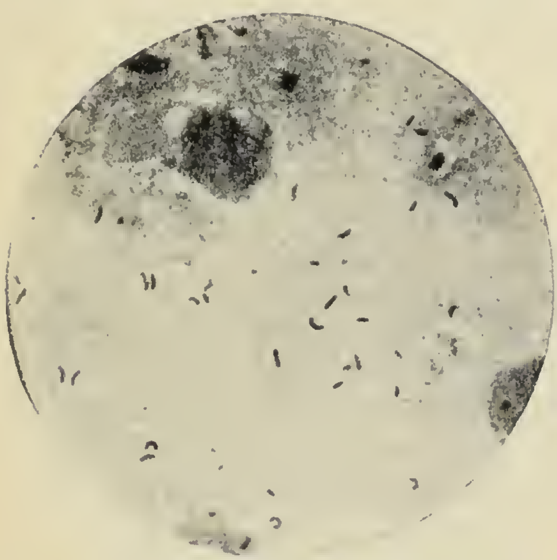

FIG. 23.—**Sirillum of Asiatic Cholera.**

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Fortunately we have not got the germ here just now, but if cholera were raging in some other parts of the world, we might easily have it introduced here. We might try to keep it out by means of Quarantine—that is, by preventing vessels from having communication with the shore—but quarantine is a very uncertain and unsafe protection, and it is those countries which have been most strict in connection with quarantine which have suffered most from these diseases. Nowadays, in Great Britain, quarantine is entirely given up, and the Continent is following her example, and relying on improved sanitation. That is what we must do here; *get our city in such a good state that if a disease like cholera gets in, it will not spread.* You will see, then, how important it is that our *water supply should be pure*, how necessary it is to close up all impure wells, and get rid of all these filthy cesspits. If cholera should ever break out here, then every one should

see that the *whole of the water* we drink, or even use to wash plates and dishes, is thoroughly *boiled*, so as to kill all the germs in it. Fruit should be avoided, and anything tending to upset the stomach or bowels, for I told you in the first lecture that anything which lowers the health, tends to favour the growth of disease germs.

TYPHOID FEVER.

But there are other diseases which come from impure water, and one of these is known as **Typhoid Fever.** This is caused by one of the straight germs, the bacilli, and it gets into the body by *water* or *milk* or *dirty food*. When it gains admission, it passes through the stomach, and enters the bowel, where it begins to grow, and form toxins, which go through all the body, and produce fever, and headache, and so on. It was this germ which killed so many of our soldiers in South Africa, many more than were killed by bullets, and it all arose from the thirsty soldiers drinking water which was not pure.

Now typhoid disease is a disease which does not appear to be very common here, but it is probably a good deal more common than we think, and it is possible that a number of the deaths which take place in the town, and which are never seen by a doctor, are due to typhoid or enteric, as it is sometimes called. I was told by one of the medical officers of the barracks, that a man died there of typhoid a week or two ago, and when the body was examined after death, it was clearly found to be that disease.

Medical men have been working at this disease for a long time so as to get some *anti-toxin*, and one has now been discovered, and it was found in South Africa that those who have been injected with this anti-toxin suffered less from typhoid fever than others.

Not only is the typhoid germ carried by water, but it is sometimes carried by *flies*. They feed on dirt and rubbish and excreta, and get germs on their legs, and then they settle on food, or on dishes, and leave a few germs there. Flies breed on dirt and decaying matter, so that, if we *keep our yards clean* we shall have fewer flies, and consequently less risk of conveying infection.

Once more I take the opportunity of pointing out how dangerous the practice of storing excreta in cesspits is, for if there are flies about, it is just the place they like to go into, and they carry the germs which they collect there, all over the place.

DIARRHŒA AND DYSENTERY.

Then, other similar diseases, such as **Diarrhœa**—which is very common here, and sometimes very fatal—and **Dysentery,** are caused by *drinking impure water.* One form of dysentery is caused by an animal parasite, a body like a very, very small jelly-fish, getting into the bowel and growing there.

We see, then, that this group of diseases is specially connected with *water*, and that if we would prevent them we must *always drink pure water.*

PLAGUE.

The next disease which I shall show you is one which I hope we shall never have here. I refer to **Plague.** It is a disease which is now principally confined to the Tropics. Formerly, as I have already told you, it used to kill hundreds of thousands of people in Europe, but now, although it finds its way in, it rarely spreads. At the present moment it exists in India, and owing to the habits of the people, it cannot be got rid of. It is also to be found in China, in Natal, and quite lately it has broken out in Johannesburg. Now, fortunately for us, there are no steamers coming directly from any of the places where there is plague, for I do not know what we should do if we got it in this place, there are so many means of spreading it. This is another disease which is very difficult to keep out, as the germ can be carried on clothes, or on cargo if it has been handled by people who have the disease ; and once it gets into a place which is not in a good sanitary state it is one of the most difficult diseases to get rid of.

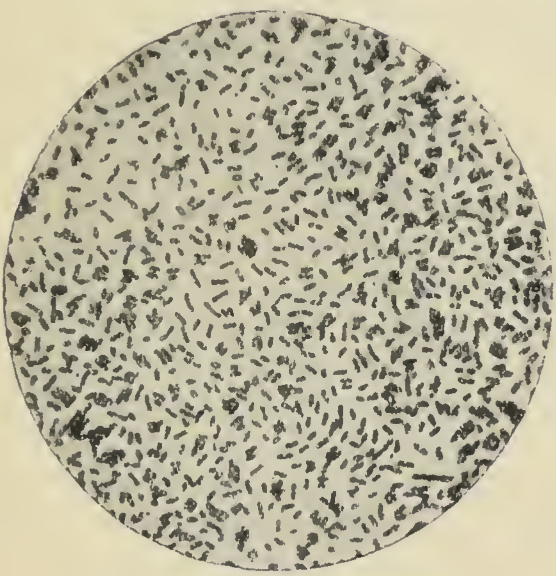

FIG. 24.—**Bacillus of Plague.**

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I show you here the germ of plague (Fig. 24), and this specimen has been taken from the liver of a rat, and you will see that it is one of the straight germs, but rather

short and fat. Now this fact that the plague germ grows in rats is very important, for there is very strong reason to believe that it is by means of *rats that the disease is spread.* Rats feed on the bodies of those who have died of the disease, or on food which has been contaminated, and then they get it themselves and die of it. Rats are generally infested with fleas, and it is supposed that these fleas bite human beings, and thus convey the germ to them. It has also been noticed that before and during an oubtreak of plague, a great number of deaths occur among rats, and if the bodies are examined it is found that they are swarming with plague germs. That is why it is so important to *get rid of all rats.* and you can now understand how readily it would spread here where so many rats live in the roofs of these old thatched houses. I remember very well that in the first native hut in which I slept in the Protectorate, there were hundreds of rats running about all night.

But, in addition, *filth and overcrowding* seem to have a good deal to do with the spread of the disease, and it is easily understood why this should be so. It is found that even if the disease gets into a place, it only affects the dirtier parts of the town, the cleaner parts escaping almost entirely. Then, doctors and nurses who move among the plague patients, who are cleanly in their persons or who work in clean, well-ventilated hospitals, rarely catch the disease. From this you will see that the overcrowding which exists in many of the houses in the Mohammedan quarter of Freetown in Mountain Cut, would be very dangerous if the disease were introduced.

One of the first things I should do if there were any chance of plague being introduced would be to ask you all to *kill all the rats* you could, so that this way of spreading plague would be got rid of; but even now, you might make a start by getting rid of as many as possible, for in any case they do not do any good.

Now this disease is such a very deadly disease, that ever since the discovery of the germs in 1894 by a Japanese doctor called Kitasato, medical men have been trying to find an *anti-toxin*, and they have succeeded in discovering two, both of which not only produce a temporary immunity—that is to say, that people cannot catch the disease—but also render it much less fatal. One of these is prepared by growing the germs in special bottles, killing the germs by heat, and then, after specially preparing it, injecting what is left. The other way is by injecting a horse with the germs. It is found that after this has been done for some time, the blood of the horse will not only prevent the disease but will cure it. The part of the blood which is used for injecting is the clear part, which

I have already described to you as the *plasma* or *serum.* Plague, then, affords a very good illustration of the beneficial effects of knowing what the actual cause of a disease is.

YAWS.

There is a disease which is sometimes found here, and which is very common at some places on the West Coast of Africa, namely, **Yaws.** I am unable to show you the germ of it, for although one germ has been described, it is not quite certain whether this is the cause of it.

Yaws is another disease which gets in through the skin, and which can be communicated from one person to another ; and in some parts of the West Indies it has spread so much, and has produced such evil effects, that special yaws hospitals have been built, just as in the case of leper asylums. The disease of yaws was evidently introduced from the West Coast of Africa into the West Indies, and it is a curious thing, that, when an infectious disease is introduced into a new community, or amongst new surroundings, it seems to find the new soil much more suitable, and the disease produced is much more serious in its effects than in the place from which it came. This was the case with yaws in the West Indies, and also with consumption, which killed West Indians much more rapidly than it did those suffering from it in England.

Yaws is another disease which is associated with *dirt*, Some of you may have seen this disease, and know that little lumps called yaws appear, which are covered with a scab, from which a clear, yellowish matter comes out. If this matter gets into a sore, or gets into the ground, other people may acquire the disease. All cases of yaws should therefore be *kept apart*, and all the *yaws* should be *carefully protected* so that the matter cannot get spread about.

SMALL-POX.

The last disease which I shall talk to you about to-day is one which you all know, for though you may not have seen the disease itself, you have seen the results of it in people who have their faces all marked with small holes, or who have even lost their eyesight by it ; I refer to the disease called **Small-pox.** You all know, too, that it is a very dangerous disease, and that when once it gets into a place it is very apt to attack a great number of people, many of whom die. I am every now and then receiving reports from the medical officers of

my staff or medical dispensers that a case of small-pox has occurred, and we then try to limit its spread as much as possible. Now there is no doubt that small-pox is caused by a germ, although we have not been able to discover it yet, and this germ can be conveyed from one person to another, sometimes by the *air*, and sometimes by *clothing*, or sleeping in a bed which has been occupied by a small-pox patient, and again by personal contact.

Although we do not know the germ of small-pox, a discovery was made many years ago by a medical man, named Dr. Jenner, which has saved many thousands of lives, for by its means we have learnt how we can practically do away with small-pox altogether. I need hardly say that I refer to **Vaccination.** Dr. Jenner observed, over a hundred years ago, that milkmaids were subject to a peculiar eruption on their hands, which they got from milking cows with a similar eruption on their teats, a disease called *cow-pox*; and he also found out that these milkmaids did not suffer from small-pox. Accordingly, in 1798, he took some of the matter from a cow, inoculated a boy, and then he ascertained that this boy could not catch small-pox. After that the practice rapidly spread, and now it is universally carried out in all civilised countries, with the result that small-pox has diminished very greatly. In the German Army, where vaccination is very thoroughly carried out, small-pox has practically disappeared. Now vaccination does not absolutely protect from small-pox, but it nearly does so, and even if one does get an attack of small-pox, it is a very mild one, and is not a serious disease. There is another thing, too, which we ought to remember, and that is, that the effect of vaccination wears off after a time, so that if a child is vaccinated when it is young, it should be *re-vaccinated* when it gets older, about 16 or 20, and when this is done, the person is very unlikely to catch small-pox for the rest of his life. I would advise all of you who have not been re-vaccinated to get it done again, so as to make yourself safe, and if you just think how, by means of three or four scratches on the arm, which will cause you only temporary inconvenience, you can protect yourself from this deadly disease, I am sure you will decide it is well worth doing. I think you will agree with me that the name of the discoverer of this wonderful preventive of a very loathsome disease Dr. Jenner, is one which should be held in the highest honour.

What are the steps to be taken to combat this disease? The first thing clearly is to *discover the cases*, and this is one of the greatest difficulties with which medical men on the West Coast of Africa have to contend.

Compulsory Notification.

There is a law in this Colony which makes it compulsory for anyone who knows of a case of small-box to inform the Medical Officer of Health, who is then able to take the necessary steps to prevent the spread of the disease. But unfortunately, it is not always possible to get the people of this country to do this, and I am sorry to think that even the educated and intelligent part of the community do not always give the assistance in this direction which they ought to do. Let me give an example of the danger of concealing a case.

In 1898 a case occurred in the Fourah Bay district. I heard accidentally of the case, but it was removed, and I could not find it. Later on, I ascertained that the man had come back and had actually died in the town. You must remember that all this time people were going in and out of the house, living next door and passing in front of it. What was the result? Within the next few weeks there were over 50 cases in the neighbourhood, and that year was the worst we have had for many years—there being 157 cases. Of these at least one-half would die, so that the concealment of this one case was responsible for the loss of between 70 and 80 people's lives. And all the punishment the woman got for concealing the case was £2 fine!

Similar cases have been occurring this year, when there has been a very serious epidemic in Freetown, and it is chiefly due to two things—first of all to a very considerable number of concealed cases, and secondly to the large number of unvaccinated people.

The first thing, then, that is necessary is **Compulsory Notification.** We must remember that every individual owes it as a duty, not only to himself, but to the other members of the community, to assist in having every case of infectious disease properly investigated, so that its origin may be discovered and the proper precautions taken. We must not forget that a disease such as small-pox does not affect the sufferer alone; that it may result in incalculable harm to others; and we must learn to be sufficiently unselfish to be willing to submit to certain restrictions, the irksomeness of isolation, or the removal to an isolation hospital. It is the dread of this which, I believe, to a large extent accounts for the reluctance to notify cases, but with increasing knowledge, I am sure this unwillingness will disappear. Not only do these necessary measures place the patient in a more favourable position for recovery, but they do much to allay that panic of which we have had such a striking example in Freetown this year

Isolation.

Having been notified of a case of small-pox, the next step is **Isolation,** and this may be carried out either at a small-pox hospital, or in the patient's own home, if it is found practicable. In the former case the patient is removed in a special conveyance, and as late at night as possible, along the most unfrequented road, so as to prevent contact with healthy people.

Disinfection.

Next, **disinfection of the infected house** must be carried out. The Sanitary Inspector visits the house, hangs up all the clothing, closes the windows and doors closely, covers the crevices, and fumigates the interior with the strong fumes of burning sulphur. The mats, bedding and clothes which have been in immediate contact with the patient are burnt, and the clothing of attendants is soaked in a bucket of some strong disinfectant. The walls, floors, beds, and chairs, are all carefully washed with a disinfectant, and finally the house itself is whitewashed. By these means we hope to destroy all the germs of small-pox which may have been left behind.

Observation.

Afterwards the house is kept **under observation** for some time, and the houses in the neighbourhood are inspected for the purpose of detecting new cases.

Vaccination.

Lastly, all the people who are living in the house, and also those in the vicinity are **vaccinated,** so that gradually a circle of protected people is drawn round the infected house. But it is much wiser not to wait for vaccination till small-pox appears, and I am only stating what is now definitely proved, that if everyone will see that he is properly vaccinated beforehand, we need not fear the occurrence of any epidemic.

We shall probably always have cases of small-pox introduced into Freetown, for we have now a long line of railway stretching into the interior, where small-pox is always to be found ; but if you, who are now studying sanitation, will assist the medical men in carrying out the measures I have indicated, and in spreading the knowledge of these measures, I am convinced that Freetown will remain free from future

epidemics of small-pox. But it is essential that the medical officers should have the whole-hearted co-operation of the townspeople.

There are other infectious diseases, such as scarlet fever, diphtheria, and so on, but I do not think it necessary they should be gone into here. In all cases the general principles are the same, and I now recapitulate them :—

1. **Compulsory Notification.**
2. **Isolation of the sick.**
3. **Disinfection** of infected house.
4. **Observation** of the neighbourhood for new cases.
5. Special measures, such as **Vaccination,** injection of anti-toxin, &c.

Summary.

Let us now take stock of the additions to our knowledge of the relationship between germs and disease which we have gained.

We have learnt (*a*) that a number of germs live in the **soil,** get into the body by dirty habits, and produce boils, abscesses, tetanus, and yaws. **Cleanliness** is the great preventive of these, and the necessity of having our clothes clean has been seen.

(*b*) We have learnt that certain germs are carried in the **air,** such as that of consumption, and that **dryness of the soil, plenty of ventilation,** and **no overcrowding** will diminish this. Incidentally the advantages of good **surface drainage** have been impressed on us.

(*c*) We have learnt that certain diseases are carried by **water,** such as cholera, typhoid fever, &c., and that the greatest attention must be given to keeping our **water** supply **good and pure.**

(*d*) We have ascertained that some diseases, such as plague, can be **spread by animals** such as rats, and that our efforts should be directed to exterminating them.

(*e*) We have learnt that certain diseases can be spread by **personal contact,** such as small-pox, leprosy, &c., and that it is necessary for the protection of the community that the **isolation** of those suffering from infectious diseases should be provided for, and that there should be **compulsory notification.**

(*f*) Lastly, we have learned that by certain special measures, such as **vaccination** or **injection of anti-toxins,** we may do much to protect people from some of these deadly diseases.

LESSON VI.

ANIMAL PARASITES—MALARIA.

We have now considered one particular form of parasite, namely, "Germs" belonging to the vegetable kingdom, and in the last lesson we studied the special germs which produce special diseases.

There is much more which I could tell you of disease germs and their action, but I have said enough, I hope, to give you some general idea of how they grow and affect human beings, of how they are spread, and how we may best prevent them. It remains for you to give these brief lessons a practical application in your daily life.

ANIMAL PARASITES.

We now come to study another division of parasite—namely, those belonging to the **animal** kingdom; and we shall find that they cause a very large number of diseases, some of them very serious, and causing a great loss of life, while others produce only a certain amount of discomfort and inconvenience. We shall also find that the conditions under which they grow are different from what we have found to be the case in germs, that the methods of transmission are different, and that, consequently, in many cases we must have recourse to other means if we are to prevent the diseases to which they give rise.

MALARIA.

And the first of these diseases to which I shall direct your attention is one which is widely spread over the whole world, which is especially prevalent in West Africa, and which has given to this Colony the unenviable reputation of the "White Man's Grave." I refer to **Malaria**.

DISTRIBUTION.

Malaria is a disease which has been widely known for many hundreds of years, and used to be much more widespread than it is now, for the area of its distribution has been gradully contracting as lands come under cultivation. In England, where it was once very common, native malaria has almost disappeared. It is found in the southern parts of Europe, and is especially bad in Italy, it is found in India, in Australia, in North America, South America, the West Indian Islands, and over the greater part of Africa, so that you see it is really a world-wide disease, and it is probably responsible in these places for more deaths than most other diseases put together. In this town I have for some years prepared tables showing the deaths from different causes, and " Fever " heads the list easily. Out of 865 deaths in 1902, 162 were attributed to " Fever," and probably this does not represent the whole, for in this town a very large number of people die without being seen by a doctor, and we cannot be quite sure of the causes of death. In addition to this, we must remember that there is a very large amount of ill-health due to this cause, and people are unable to do their work properly, and thus the prosperity of the community is hindered.

There is another very important point—namely, that the malaria parasite is much more common among children than among grown-up people, and we find that in 1902, out of 302 deaths which took place under the age of 5 years, 75 were ascribed to fever. That is to say, 25 out of every 100 of the deaths among children were due to fever. It is now a recognised fact, not only here, but in other parts of the world, that children suffer much more from malarial fever than adults, and as I shall show you later, this is a very important factor in connection with the spread of malaria.

HISTORY.

Now you can understand that with such a widespread and fatal disease, medical men have been trying for years to find out what causes it and how it spreads, but it is only within the last few years that our knowledge has become definite. From the fact that these fevers were more common near swamps, it was long attributed to the bad air and smells arising from them, and it is from this it got its name—*mal*, " bad " ; *aria*, " the air." Then some doctors thought that they had found a germ, which they called the *Bacillus*

Malaria, and which they believed produced the disease, but we now know that this is not the case.

Well, twenty-five years ago, a French doctor, Dr. Laveran, set himself to examine the blood in a number of cases of fever, and eventually he found that in the blood there were a number of small bodies, which were evidently animal parasites, and which I shall describe to you presently, and that these bodies were never to be found in the blood of people who had no fever. Shortly after he had published these discoveries, others began to look for them, and they were found in the blood of fever patients in India, in Italy, in America, in West Africa, and in fact in every locality in which malarial fever occurred. Still we were in the dark as to how these bodies got into the blood, and how they grew, and there were all sorts of ideas about them. Some thought the parasite was in the earth, and got carried up into the air and breathed in, while others thought it got into the body by drinking water, but it could never be found in the earth or in water. Then, in 1894, Sir Patrick Manson, after a careful study of the bodies in the blood, came to the conclusion that they must live outside the body in some insect, and, as they could not leave the body themselves, they must be taken out by the insect. Accordingly, as the *mosquito* is common in malarial countries, he suggested that this insect was *the carrier of the disease*.

Dr. Ross, in India, having set himself to study the subject, fed a number of mosquitoes on blood containing malaria, and after examining hundreds and hundreds of them, he found that the parasites grew in the body of the mosquito, underwent certain changes, and that the mosquito could then give the same disease to another animal. These discoveries were confirmed in Italy and in other parts of the world, and it was further found that it would only grow in a *special kind of mosquito*.

Lastly, two experiments were carried out by Dr. Manson, which I think you will agree with me are conclusive.

I. First of all, some of these special mosquitoes were grown from the egg, and were allowed to bite a patient in Rome, suffering from a mild form of malarial fever. The mosquitoes were then caught and put in special cages, and sent to London. There they were let loose in a mosquito net, and two gentlemen, one of whom was Dr. Manson's son, slept under the net. Now, neither of these gentlemen had ever had fever, or had ever been in a malarious country, and yet in a few days they developed malarial fever, and on examining the blood, the *same* kind of parasites were found as in the blood of the sick man in Rome who had been bitten. Malarial fever does not exist in London, so that you see that these

two men could only have got the fever in one way—namely, from the mosquitoes which had come all the way from Rome.

II. The second experiment was different. A special house was built and sent out to Rome, where it was put up in one of the most unhealthy places that could be found. This house was made mosquito proof by means of wire netting, and two English doctors and their servants went to stay in it during three of the most unhealthy months of the year 1900. They took no medicines, took no quinine, and the only precaution was that they never left the house before the sun rose, and always went inside before the sun set. That is to say, they were always inside the wire netting just at the time that the special malaria mosquito is in the habit of going out to feed. Now what was the result? Not a single one of the inhabitants of this house took fever, whilst their neighbours, the Italian peasants who were living in their ordinary houses, each and all suffered from the disease. These experiments, then, conclusively prove two things—first, that *mosquitoes are capable of carrying malaria;* and secondly, that *you can protect yourself against malaria by protecting yourself against mosquitoes.* These experiments have been repeated more than once elsewhere, so that we may say now that the so-called mosquito theory is *no longer a theory*, but a *proved fact*, a fact proved as conclusively as the contagiousness of small-pox.

VARIETIES OF FEVER.

There are several kinds of malarial fever each with its special parasite, but I need not describe them all to you, as I am afraid it would only confuse you.

Most of you have had an attack of fever at some time or other, and know that it begins very often by feeling out of sorts, with perhaps headache, and pain in the neck or back or legs, then you feel cold, sometimes so cold that you shiver all over, or even shiver so violently as to shake the bed. The next stage is the hot stage, when the skin feels very hot and dry, the head is aching, the heart beating rapidly, and there is a feeling of intense discomfort. After a varying period, the skin begins to get moist, and soon a profuse perspiration sets in, the temperature falls, and the person gets cool and feels much better. Next morning, or the day after, the fever comes back again if it has not been properly treated. That is a description of a *mild form of fever* caused by the mild parasite.

Sometimes the fever instead of coming down remains high all the time, there is very little sweating, there is vomiting and jaundice, and if the person does not get quinine he may die of the fever. This is the *severe* or *malignant form* of fever.

Then other cases are still more serious, and we have what is known as *Blackwater Fever*.

There is another form, and you find it very often in children here. Instead of getting bad attacks of fever, they get very slight ones, but the spleen gets big, and you can feel a hard lump in the belly due to this, the blood gets very thin and poor, and if you look inside the eye you will see that it is pale instead of red, and the child becomes weak, loses its appetite, and does not run about and play like a healthy child. This is what we call *Malarial Cachexia* or *Debility*, and is very common among children here, and very bad for them.

THE PARASITE IN THE BODY.

Now I will first show you the parasite in a **mild** fever. If you prick the finger or the ear of a person suffering from one of these attacks of fever, just before the shivering fit is expected, spread the blood out in a thin layer under the microscope and examine it with a very strong magnifying

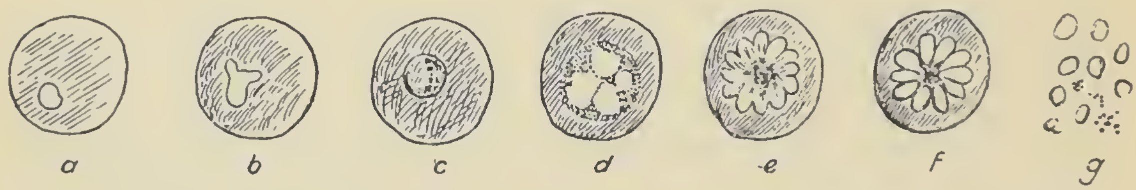

FIG. 25.—Diagram of growth of mild parasite in a red corpuscle

power, you will find that some of the red blood cells, which I have already told you about, have got little *white bodies* on them or on the outside of them (Fig. 25 a.). They gradually increase in size, and while at first they were quite clear, they now begin to show spots of very dark colouring matter, or pigment, which is called "**melanin**" which you see very clearly in these specimens (Fig. 25 c. d. e. f.). Sometimes you will find that, instead of one parasite, there are actually two invading a blood cell and eating it up.

The next step is that this parasite, as it gets older, begins to divide up into a number of *small round bodies*, and all the black pigment collects in the centre, and we have what is called a "**rosette**" body because it is like those ribbon

rosettes which you sometimes pin on your coats (e and f.) Then this body bursts and lets all the little **spores** free in the blood (g.) After a little while they fasten on to new red cells and begin to grow again, and go through the same cycle which I have just shown you. Now you can understand that, if this is going on for some time, the parasites each eating up a red cell, very soon the blood will get very thin, owing to the destruction of the red cells.

There is an important thing to remember about these spores, and that is that they sometimes *hide for a long time in the marrow* inside the bones, ready to come out and grow, if the person gets at all out of sorts, say from a chill, over-work and so on.

That is a description of the mild or benign form, and the severe or the **malignant** form grows in much the same way, only there are slight differences in the parasite, it generally grows much more quickly and has not so much of the black pigment. It forms little rings, and sometimes there are several parasites in one red cell. It is this malignant parasite which is the most common here, and which produces the dangerous form of fever.

SEXUAL FORMS.

Now this will go on time after time in the blood, but if that was all, it would only affect that person, and no one else would get the disease, for this parasite does not appear to have the power of getting out of the body ; it does not come out by the breath or by the bowels, or by the kidneys or by the skin. If, then, this was the whole history of the parasite, it would soon disappear, for it would either kill the person, or it would die out of itself. But in every animal Nature has made provision for the propagation of the species, and this animal parasite of malaria is no exception. If you examine the blood in a *benign* case at certain stages you will find that the parasite, instead of forming the rosette body and then bursting into young ones, forms a large round body or "**sphere**" full of pigment (Fig. 26 a.). This is the *sexual form of the parasite.* If it is left in the body it does not develop any further, but in time would gradually die, only we must remember that it is very persistent, and may sometimes be seen a long time after the fever has stopped. Well, if blood containing these bodies is taken *out of the body* and watched, after a little while the pigment is seen to dance about rapidly and then suddenly a number of whip-like bodies, like tiny worms or snakes, are pushed out at the side. These

are called "**flagellæ**" (Fig. 26 b). This is the male form of the benign parasite.

The *malignant* parasite is a little different; instead of forming a round body or sphere it forms a "**crescent**" (Fig. 26 c). If we watch this *outside the body* we find the same thing happening in the male, flagellæ are formed, which eventually break off and swim about of themselves. These crescents, too, are very persistent in the body.

FIG. 26.—Diagram showing benign (a & b) and malignant (c) sexual forms.

We see, then, that the malarial parasite *in the body* has two separate stages, first the one which goes on over and over again *in* the blood cells, and second, the sexual forms, which do not reach full development until they are taken out of the human body.

THE PARASITE OUTSIDE THE HUMAN BODY.

Now we are in a position to study this development of the parasite and learn how it gets back into the body, which, as I have already told you, is effected by means of the **mosquito**.

DESCRIPTION OF MOSQUITO.

You all know what a mosquito is, you see them every day and hear their irritating buzz as they fly about before settling on your face or hands and biting you. But I have been astonished to find how few of you know how a mosquito grows, and where it comes from, and it is very important that you should know this in connection with the prevention of malaria. Most of you have seen in tubs or barrels of water, which have been allowed to stand for several days,

a number of little wriggling animals which go to the bottom when they are disturbed, but I am sure that many of you will be surprised when I tell you that these little wrigglers eventually become mosquitoes.

A mosquito's life may be divided into four, the egg, the larva, the pupa, and the full-grown mosquito.

First of all, the female mosquito lays a number of eggs, 50 to 400, on the surface of some quiet pool of water or in a barrel, and in a day or two these develop into the little wriggling bodies of which I have just spoken, and which we call **larvæ.** In Figs. 27 and 28, I show you pictures of two

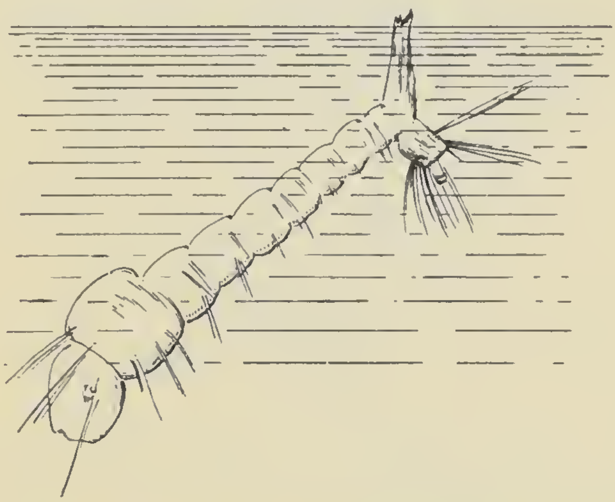

FIG. 27.—Culex Larva, head downwards, breathing tube at surfaoe.

different kinds of larvæ, the one with the head lying down is the larva of the **Culex** Mosquito, the one lying flat on the surface, that of the **Anopheles.** It is very important to remember this difference, as in this way, the two kinds of mosquitoes can be distinguished, even at an early stage of

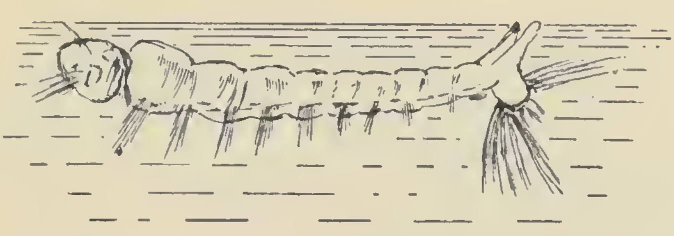

FIG. 28.—Anopheles larva.—Level position at surface.

their existence. Larvæ have to come to the surface to breathe, and you will notice a long straight tube stretching from the tail of the culex to the surface of the water. That

is the breathing tube. The anopheles has a much shorter breathing tube.

After a few days the larva changes its shape and becomes a pupa, as shown in Fig. 29. Notice here, again, the two short breathing tubes going to the surface of the

FIG. 29.—Pupa.—Resting position at surface.

water. Later on we shall see that by spreading kerosine on the surface of the water we can destroy them very easily.

After a day or two the pupa comes to the surface of the water and remains there, and shortly a full grown mosquito comes out of it, remains for a few seconds on the surface of the water and then flies away, leaving the empty shell behind.

A mosquito consists of (*a*) the **head** from which projects the (*b*) **trunk** or **sting,** (*c*) the chest or **thorax,** and (*d*) the **abdomen** containing the stomach.

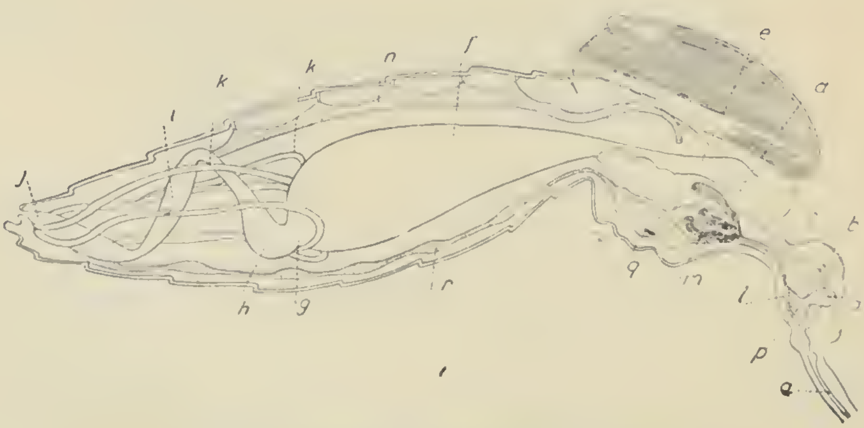

FIG. 30.—**Section of Mosquito** (Manson).
a—Mouth ; *l*—Salivary duct ; *m*—Salivary gland : *f*—Stomach.

In the chest are what are known as **salivary glands** (Fig. 30). You are aware that everybody has got glands in the neck which sometimes swell. These are the salivary glands, which make the saliva or spittle, and thus the mouth is kept moist. The mosquito has got similar glands and when he wishes to bite you, he sometimes finds some difficulty in getting his little trunk in, so he squirts in a little salivary juice which acts as a kind of oil, and lets the trunk go in more easily. The juice is irritating, and causes itching and swelling, and also serves the purpose of bringing more blood to the part. You will understand how important this is shortly.

I have already mentioned to you two kinds of mosquito, the culex and the anopheles, and it is very necessary that you should be able to distinguish between the two, as it

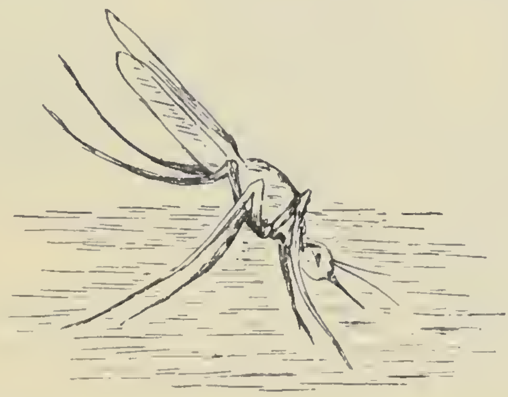

FIG. 31.—Diagram showing resting position of Anopheles.

is the latter only which causes malaria. First, anopheles has *spots* on the wings, while the common culex has *none*. Then the position is very characteristic, the anopheles stands

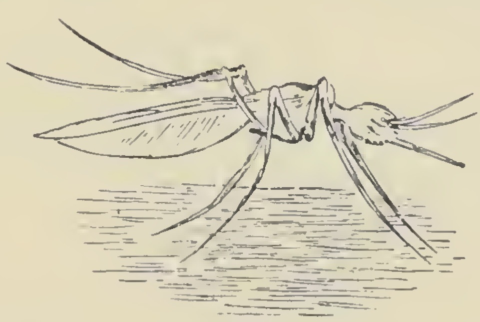

FIG. 32.—Diagram showing resting position of Culex.

as if it were *boring its head* into the wall (Fig. 31) the head and trunk almost forming a straight line, while the culex stands *flat along the wall* (Fig. 32), and is rather hump-backed.

We thus see that we can distinguish these two varieties of mosquitoes, both when they are babies and when grown up.

There is another mosquito called **Stegomyia,** which is very common here and carries Yellow Fever. It has got white stripes upon its belly and chest, and white bands on its legs.

It is only the female mosquito which bites, the male never does. The latter can be distinguished by two large feathery projections sticking out at the side of the head.

Mosquito larvæ will breed in barrels, old tin pans, empty bottles, old pots, calabashes, in fact, in anything that will hold water. They also grow in pools on the ground, in the gutters at the sides of the streets, and along the streams which run through Freetown. Anopheles frequent quiet slow-moving streams, or the pools at the side, and specially where there is grass or weeds, when you will find them sheltering round the stems; while culex will more often be found in artificial collections of water, such as barrels. Cesspits, too, breed mosquitoes during the rains when water gets into them, and larvæ will generally be found in wells, especially if they are not much used.

We see, then, that in order to grow mosquitoes, water is necessary, and we know that during the dry season they are much less numerous than during the rains. During the "dries," when there is very little water except in the streams, many mosquitoes hide themselves in the houses, in holes under trees, and in any sheltered spot and go to sleep, until the rains come when they begin to breed again. This is called "*hybernating*," and by this means the species is preserved from one season to another. We do not know exactly how long a mosquito will live, but it is much longer than has hitherto been supposed, and probably extends to months.

We shall see the importance of knowing something of the life and habits of mosquitoes when we come to study the best means of exterminating them.

DEVELOPMENT OF PARASITES OUTSIDE THE BODY.

Now, we can go on to study the life of the malarial parasite *outside the human body*, that is to say, inside the body of that particular variety of mosquito called the anopheles.

First of all, one of these mosquitoes settles on a person who has malarial fever, inserts his sting through the skin, and sucks in a supply of blood. Should this blood happen to contain what I have described to you as the sexual forms of the parasite, certain changes take place in the stomach of the mosquito. The male sphere or crescent forms **flagellæ**, these break off, and seek out a female sphere or crescent into which they disappear.

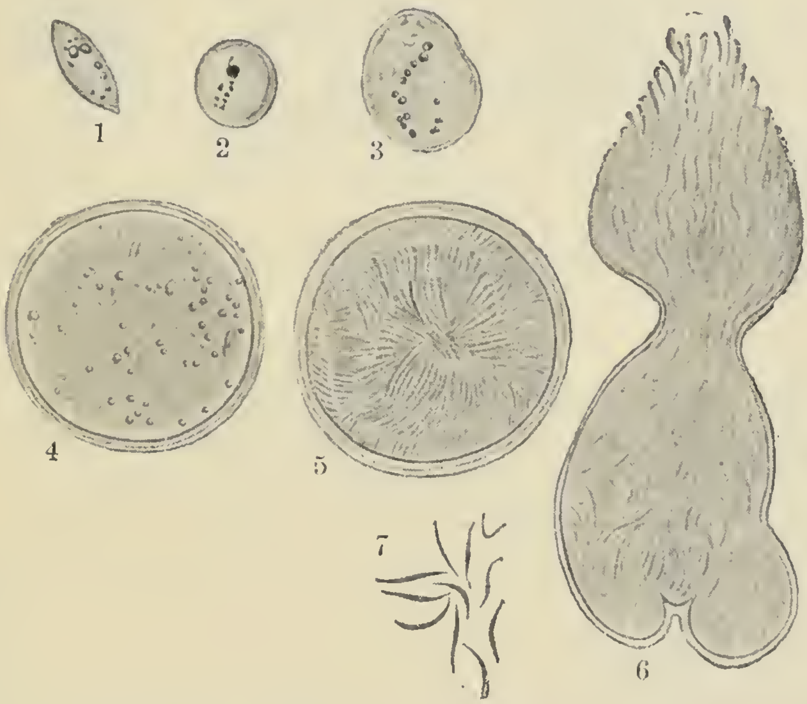

FIG. 33.—Evolution of crescent parasite in Mosquito (Manson.)

A round body called a **Zygote** is then formed (Fig. 33, 2, 3, 4) which gradually gets larger and larger, and eventually goes right through the stomach wall. In Fig. 34 I show you a mosquito's stomach with numbers of zygotes in it. As the zygote ripens, a number of small bodies packed closely together are seen to be forming in it, bodies just like a lot of little spines or needles, "**germinal rods**" (Fig. 33, 5), and at last the zygote bursts (6), all the little needles (7), are set free in the body cavity of the mosquito, and gradually work their way into what have been described to you as the salivary glands of the mosquito. Now, you are able to understand how they get back into the human body.

An infected anopheles bites a healthy person, and as he squirts the salivary juice through his trunk a number of the germinal rods are carried in with it and find their way into the

blood, where they attack the red blood cells and grow in the manner I have described to you.

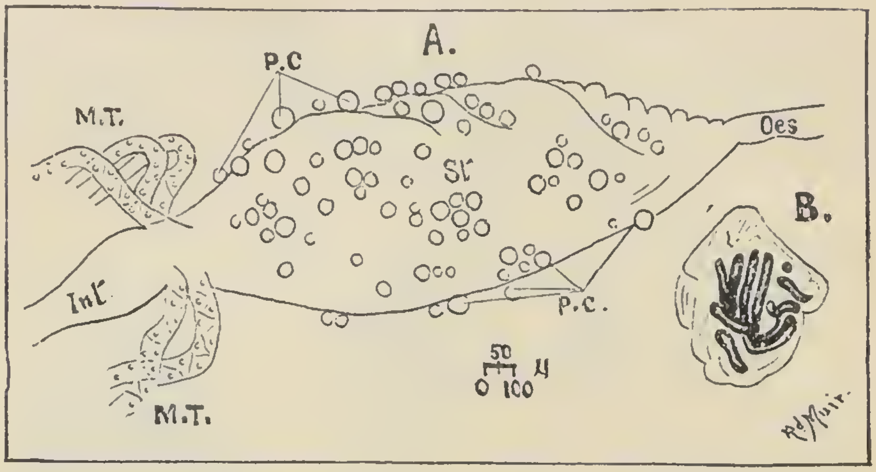

FIG. 34.—Stomach of Mosquito after infection with parasites, showing Zygotes (Manson).

There are then, two distinct life histories of the malarial parasite—*in the body*, the spore attacking the red cells, growing larger, forming rosettes and again producing spores; *outside the body*, sexual forms from the blood, zygotes in the mosquito, and germinal rods, which are again injected into the blood.

For the production of malaria two things are required, an individual suffering, or who has suffered from malarial fever, with sexual forms in his blood, that is to say, an **infected individual,** and a special kind of mosquito which has fed on such an individual, an **infected anopheles**. If we have no infected people, it does not matter how many anopheles there are, for they cannot become infected; and on the other hand, if we have no anopheles, it does not matter how many infected people we have, for the disease cannot be transmitted and would die out of itself. It is evident, then, that malaria must be attacked in two ways, first of all, *in the infected body*, and secondly, *in the infected anopheles*.

EFFECTS OF MALARIA IN THE HUMAN BODY.

But before we discuss the prevention of malaria, let me tell you a little more about the effects of the parasite in the human body.

You have learned how it attacks the red cells, and gradually eats them up and destroys them. By this means they are reduced in number, and what is called **Anæmia** or **Bloodlessness** is produced. The person becomes pale,

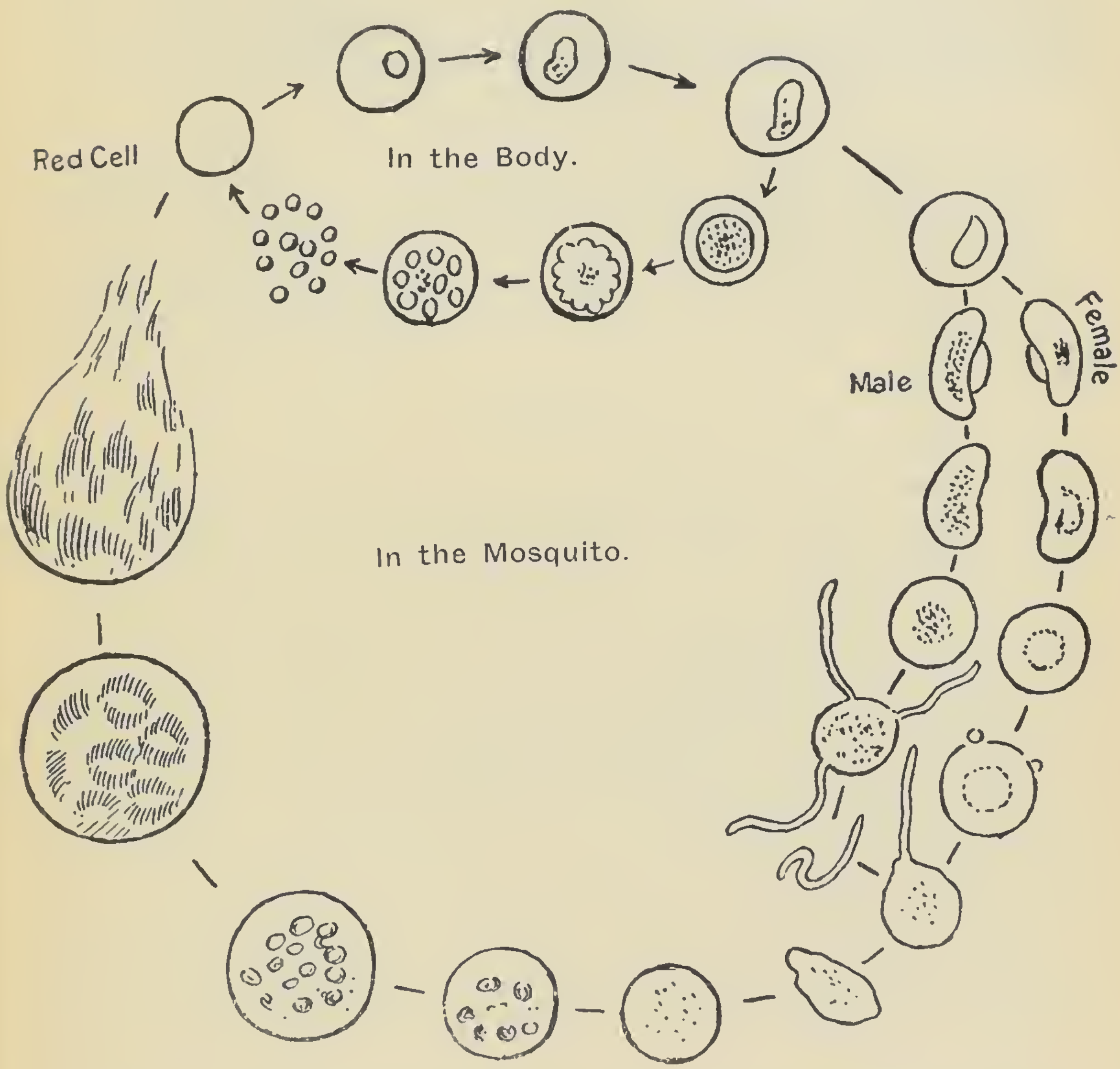

FIG. 35.—Diagram showing the cycle of the malarial parasite in human body and mosquito. (Manson.)

weak and languid, in consequence, and if it were allowed to go on unchecked, he would eventually die through want of blood.

You also remember that the parasite manufactures a black pigment called **"melanin."** This gets into the internal organs—the liver, the spleen, and the brain, and clogs them up, and if you examine them with a microscope you will have no difficulty in finding masses of this pigment. It

naturally interferes with the proper working of the different organs—the brain does not think properly, the liver is enlarged and works sluggishly, the digestion is interfered with, and the spleen is enlarged, so that even after the fever has disappeared we have the effect persisting for a long time.

Then the toxins produced by the parasite cause the **temperature** of the body to rise, and occasionally it goes so high that the person dies of the fever alone.

LESSON VII.

TREATMENT AND PREVENTION OF MALARIA.

Malaria, then, is a disease which has very serious effects, not only on life, but on health, ruining the constitution, and rendering the individual unfitted for his daily work. How can we best prevent it? Let us first of all consider how to attack it **in the body.**

QUININE.

Fortunately we have a very valuable drug which, not only cures malarial fevers, but will also prevent them, and I am sorry to say that it is a drug which is not nearly so much used by the natives of this place as it ought to be. I have heard natives say to me "White man medicine not good for black man," but when I tell you that **Quinine** was originally a *native* medicine, you will see how untrue this saying is. When the Spaniards conquered South America in the seventeenth century they suffered a great deal from malarial fevers, and they found that the natives of the place, the Indians, used to cure themselves by boiling down the bark of a tree, and drinking the infusion. This tree was the Cinchona tree, and the Spaniards found it so efficacious that they used it themselves and introduced it into Europe. From this bark the drug called quinine is prepared, so that quinine is really a *native remedy.*

Now, if you give quinine to a patient suffering from malarial fever, and at the same time watch the parasites in the blood, you will find that they gradually shrivel up, get fewer in number, and eventually disappear. *They have been killed by the quinine.* And, not only that, if taken early it will cut short the attack, and will *prevent the sexual forms from growing*, and thus prevent its transmission by the mosquito.

In addition, it has been found that small *daily doses* of quinine will prevent the parasite from growing, and a person from having fever. I know many persons who have taken quinine regularly every day while out here, and they have never had an attack of fever, although they must have been bitten at some time or other.

I have told you that *children* suffer very much from malarial fever in this town, and there is no doubt whatever that they are the source from which the greater number of mosquitoes become infected. If you will come to the hospital any morning at the out-patient hour I will show you half-a-dozen children with large spleens, and if I examine their blood I am sure to find in some of them the malarial parasite.

I have persuaded one or two people here to give their children small doses of quinine regularly, and the effect on the children's health has been surprising. Whereas, formerly, they were always ailing and pale, and easily tired, they have become stronger, and their appetites have been improved, and they rarely suffer from fever. If I could get the people of this town persuaded to give quinine regularly to their children I should feel that I had done a great work, and had done something not only to diminish the death-rate among children, but also to prevent the disease among grown-up people.

Effects of Quinine.

But I hear some of you asking—Does not quinine do you harm? Well, taken properly and carefully, *it does not*. If taken in considerable doses it causes the head to ring and a certain amount of deafness, but this is only temporary, and passes very quickly, and surely a slight inconvenience of this kind is much better than the serious damage which fever does to the blood and all other organs of the body.

And there is another thing which vexes the souls of some inquiring gentlemen. They ask whether, if they take quinine regularly, they will not require more when they actually get a dose of fever. If you will think of the action of quinine you will see that this cannot be the case. Quinine kills the parasite, and the dead parasite cannot get accustomed to the quinine. If you get a number of parasites into the blood, and get fever, these new parasites have not been exposed to the quinine, so what chance have they had of getting accustomed to it? On the contrary, you will probably require less quinine, for the parasites are not likely to flourish in your blood if you have been in the habit of taking quinine. Let me try and make it clear by another case. If you have, say, half-a-dozen rats in your house and you wish to kill them, you put down some rat poison. They eat it, and die. Well, you do not say that the house has got accustomed to the rat poison, and that next time there are rats you will require more poison. You know quite well that if rats come again you will only have to put down the same quantity of rat poison to kill them,

for the new rats have not got accustomed to the poison, and it is exactly the same with the malarial parasite and quinine.

Let me urge upon you, the **necessity of using quinine** more freely than you do. Those of you who can buy it should do so, and those who cannot may have it at the Colonial Hospital. The Government will not grudge the supply of quinine if by its means we can make the town more healthy.

OUTSIDE THE BODY.

But everyone will agree that it will be still better if we can prevent the parasite from getting into our bodies, and this of course simply means that we must **prevent the mosquitoes from biting us.**

Mosquito Nets and Mosquito-Proof Rooms.

Now, there is a fortunate thing about the anopheles mosquito, namely, that it generally comes out at night to feed. It does not always do this, but this is its general habit. Well, we all go to bed at night, so that it is possible to protect ourselves from the bite of the mosquito for at least eight hours out of the twenty-four, and we can thus escape infection for a third of our life. We can do so by means of *properly made* **mosquito nets.** They must be all in one piece, have no holes, and be tucked in all round the mattress. Some people say that they feel it hot inside a mosquito net, but there is a very slight difference of temperature, and you soon get accustomed to it, and surely it is worth while taking a little trouble to protect yourself for a third part of the day. It is particularly important that all children should sleep inside mosquito nets, and I hope all of you here will use your influence to get people to do this. It will cost a few shillings at first, but health is well worth it, and it will save doctors' fees and medicine. If you prevent mosquitoes biting children you prevent them from getting infected, and thus one source of the disease is cut off. Experience has now definitely shown that *people who use properly made mosquito nets suffer less from fever than those who do not.*

There is another way in which you can protect yourselves, and that is by making the room or house **mosquito proof** by means of a wire gauze. This has been done at Cline Town with great benefit, and I have made my bedroom mosquito proof in this way. In the unhealthy parts of Italy many of the houses along the railway occupied by the railway staff, have been made mosquito proof, and it has been found that without any doubt they enjoy much better health than those who are not protected in this way. Some people argue

that it interferes with ventilation. Well, it must do to some slight extent, but it is wonderful how very little it does, and we can leave the glass windows wide open all the time. To those who can afford it, and who have suitable houses, it is a most valuable means of protection.

Certain plants are said to keep away mosquitoes, and lately a plant which grows here, the basil plant, or, as it is locally known, tea bush, was much praised. I made some careful experiments to see if mosquitoes really disliked it, but I found it had not the slightest effect upon them. I would strongly advise you to *stick to the mosquito net* and *not put any faith in these plants.*

DESTRUCTION OF MOSQUITOES.

We have seen, then, that we can attack malaria in the body, and can prevent mosquitoes from biting us, but I am quite sure that it has occurred to all of you that really the best way of all, would be to get *rid of mosquitoes entirely.* If we have no mosquitoes we could have no malaria. Is this practicable? I am sure it is, if every person in the town will help, and will see the larvæ are not allowed to breed in his yard.

Do not allow standing water to collect.

You know now that the larvæ of mosquitoes grow in tubs and barrels and pools, that they take some days to grow, so that if we *empty all standing water* once a day we prevent the mosquitoes from growing. I am glad to say that the people of this town are gradually getting to know that they must not have these larvæ in their yards, and some of them try to keep their barrels free from larvæ, but many are very careless, and I hope it will be made a punishable offence to have mosquito larvæ breeding in the yard, for they are just as dangerous in causing disease as a concealed case of small-pox is. I trust that all of you will go round your yards, and if you find larvæ you will empty the vessel on the ground.

Provide proper covers.

Then all vessels intended for holding water should have a *proper cover* made of gauze or wood which will keep out mosquitoes, and this, too, should be compulsory. If the mosquito cannot get to the water to lay eggs there will be of course, fewer mosquitoes, for one mosquito will lay hundreds of eggs. If you prevent even twenty mosquitoes getting at water you will prevent thousands of eggs from hatching out,

and you will see that this will soon make a difference in this town. It is astonishing how readily mosquitoes will breed in the most unlikely places, in the plates below "coolers," in flower vases, in the tubs we put flower pots in, and all of these should be carefully watched.

Sweep out the pools.

Then you should see that there are *no pools in your yards*, and it would be a very good thing for the health of the inhabitants of this town if all yards were paved. You should see that all **holes are filled up** with earth or stones, so that water cannot lie in them, and if this cannot be done the holes should be **swept out daily**. You should also see that there is a channel made into the street gutter to carry all the rain-water off as quickly as possible. A common place for the anopheles mosquito are the little springs we find in the yards in some parts of the town. Now that we have a good water supply I hope that these will all be filled up, but in the mean-time they should be kept quite clear of weeds and grass, for, as I have told you, the anopheles mosquito prefers weedy pools.

Close the Cesspits.

There is another place in which larvæ breed, and that is in wells, especially if they are not used, so this is another reason why these wells should be closed up. *Cesspits*, too, breed mosquitoes, especially in the rainy season, when water gets into them. They do not breed the malarial mosquito, but they breed other varieties, and, as I shall show you later, other diseases are produced by the common mosquito. It was found in Ismalia, in the Suez Canal, that the great majority of mosquitoes came from the tanks in which excreta were received. I hope that very soon this matter of the closure of cesspits will receive the attention which it deserves.

Put the street gutters in order.

Then all the *street gutters* require to be put in order, and proper cement drains made which will carry off the water thoroughly and quickly, so that the surface of the streets can become dry, and pools will not be left for mosquitoes to breed in. This is gradually being taken in hand, and a number of streets have been done in the Grassfields and elsewhere, but it is not getting on so quickly as I should like, for I find that wherever these cement drains are made the anopheles larvæ do not breed readily. For one thing weeds do not grow easily in the drain, and for another they are easily swept out

and kept clean. Earth or rock gutters are much more unsatisfactory, for they very soon become irregular and form depressions in which pools of water form and larvæ breed. It is this time of the year, when the rains are not very heavy, which is most likely to produce mosquitoes, for there are just enough showers to keep the pools going. In the dry season the pools soon dry up, while in the heavy rains the pools very often get thoroughly washed out.

Then I notice that at nearly all the new standpipes pools of water form, and these drains especially will have to be seen to, for though the pure water supply will remove one danger, the pools will add another.

Attend to the streams.

Lastly, another source of mosquitoes are the streams running through the town, Granville Brook, Sanders' Brook, and others. You will find mosquitoes, and very often the anopheles, breeding all along their courses. Well, dealing with these is a very big job, and building them up in such a way that pools would not form would be a very great engineering enterprise, and I understand would cost a lot of money. Still, I am in hopes that it will be undertaken some day, and, in the meantime, I do the best I can by having men constantly going up and down these streams, clearing out the pools and putting kerosene on them, and the more men I can persuade the Municipality to let me have, the more satisfactorily will this be done.

Use of kerosene.

This brings me to another method of killing mosquito larvæ, and that is by placing *kerosene on the top*. I have told you that the larvæ have to come up to the surface to breathe. Well, if you put a thin layer of kerosene on the surface the larvæ are unable to breathe, and they die of suffocation, so that is a very simple method of killing larvæ in pools which cannot be swept out, and I trust that you will bear it in mind, and use it whenever you have an opportunity. There are other things which can be placed in water—tar, carbolic, and so on—but the easiest and most convenient is kerosene.

DIFFICULTIES IN ACCEPTING MOSQUITO THEORY.

Now, before I close this lesson, there are one or two points to which I wish briefly to allude, one or two difficulties which people have in accepting these facts.

Is the mosquito the only way?

First of all, some one will ask you, is this the *only* way we can get fever, because, if not, what is the good of these precautions? Well, we cannot say definitely it is the only way, but we *can* say that it is *probably* the only way. Since we have known the relation between the parasite and the mosquito, experiments have been made in many directions, and with many insects, but it has never been found possible to transmit it otherwise. But in any case, since we know definitely that the mosquito is one way, why not take precautions against it? Sir W. M'Gregor used an illustration which struck me very much. If some of the leading gentlemen of this town went out for a sail in a boat, and when they got far away from the shore, one of them pointed to a crack in the bottom through which water was pouring, and said "There is a leak, let us stop it," what would you think if all the others said, "Never mind it, let us look for some other leaks first," and gradually the boat filled and sank? You would say that they were fools. And so it is with malaria. We *know* that it is communicated in one way by mosquitoes, and yet some people say, "We will not do anything because there may be other ways." I ask you, is that a sensible position to take up?

Infected mosquitoes necessary.

Then another person will inform you triumphantly—"*I am often bitten by mosquitoes and never get fever.*" Now we must remember two things, first, that a person must be bitten by a *special kind* of mosquito, and, second, that that mosquito must be an *infected* one. You may be bitten by dozens of mosquitoes so long as they are not infected, but once get bitten by an infected mosquito, and you get the parasite in your system.

But there is another reason. You remember I told you about phagocytes; well, if you are in a good state of health the *phagocytes* are quite capable of dealing with a certain number of parasites and destroying them.

And there is one more explanation, and that is that certain people are *not susceptible* to the parasite, it does not thrive in their body, and they do not get fever; but these people are very rare, and I would not advise you to count upon yourself as being one of them.

Then, again, some people will say the opposite—"I am never bitten by mosquitoes." Well, when they say that, I

do not believe them ; it simply means that their skins are not very sensitive, and that they do not feel the bites.

Do travellers get malaria in uninhabited places?

Another difficulty is, how can we account for travellers getting fever in uninhabited places? Well, it is doubtful whether they ever do get fever in uninhabited places, as they have always passed through inhabited places first and probably have had fever before, and you will remember that I have told you that the spores may hide in the bones for a long time, and come out when they find a favourable opportunity. This also accounts for people getting fever at sea or far away from a malarial country. On the other hand, there is just the possibility that certain animals may have the same parasite and communicate it to human beings. One thing is certain, that *wherever malarial fevers exist, there the anopheles mosquito has been found when it has been looked for.*

There are many other interesting points in connection with malaria, but time forbids me to go into them. We have seen what causes malaria and how it is transmitted, and we have learned that there are a number of simple and easy methods of reducing the number of mosquitoes in this town ; all that they want is a little observation, a little patience, a little care. Every mosquito killed, every mosquito prevented laying its eggs, means so many hundred fewer mosquitoes in this city. If you believe what I have told you, and you must believe it after I have shown you the actual parasite in all its stages, you must know that mosquitoes do a great deal of harm, and you will feel that it is your duty to assist in exterminating them. If, then, every one of you will see that all vessels containing water are emptied regularly, that all pools are swept out, that no vessels in the house are allowed to breed mosquitoes, and will also try to get your neighbours to do the same, we shall have made a good beginning in this direction. We are doing all we can to improve the health of this town ; I appeal to you to give us this little assistance, by devoting every day a little time to spreading the knowledge of the dangers of the mosquitoes, and by aiding in their extermination.

LESSON VIII.

ANIMAL PARASITES—*continued.*

The next animal parasites which we shall study are two, which, like the malarial parasite, live in the human blood.

SLEEPING SICKNESS.

The first parasite is that of **sleeping sickness.** You have all heard of this disease, and it is very important, for within the last few months it has been found to be not uncommon in this Colony. Whether it has always been in the place or whether it has been recently introduced it is difficult to say. It is found up in Senegambia, is very common in the Congo, and of late years has appeared in Uganda. Sometimes it attacks a whole village, and nearly all the people die, for up to the present we know of no cure for it.

The name is taken, as you are aware, from the principal symptoms of the disease, sleepiness. A person gets the parasite into his blood, and for a long time it appears to do very little harm, except that there are slight attacks of feverishness. Then he begins to get a little bit weak, easily tired, and feels disinclined to work. Soon he shows a tendency to fall asleep at unusual times, and this goes on increasing, so that the patient wants to sleep all day and all night, has to be wakened to take his food, and even then, in the middle of his meal, he will stop chewing, and go to sleep with the food in his mouth. Finally, he gets weaker and weaker, and dies of exhaustion. I think you will admit that this is a very terrible disease, but we think we have now discovered the cause of it, and we may hope soon to be able to find a remedy.

Fig. 38.—Parasite of Sleeping Sickness: Trypanosoma.

The cause of the disease is a parasite called a **Trypanosoma** (Fig. 38). In 1902 Dr. Ford in the Gambia found a parasite which he had never seen before in a patient, and later on, this parasite was recognised by Mr. Dutton, of the Liverpool School of Tropical Medicine, as a Trypanosoma, a parasite

which is known to grow in the blood of the lower animals. In South Africa, and also on the Gold Coast, it causes a special disease in horses, called Nagana, which is very fatal, and which is carried by a special fly called the **Tsetse Fly.** It is also a disease which is common in rats.

When I arrived from leave three months ago I found a case of sleeping sickness in the wards which had come from the Congo, and on examining the blood I found on more than one occasion numerous Trypanosoma, and I shall put one of them under a microscope for you to see the parasite itself.

Now it is only within a few months comparatively that the cause of this disease has been discovered. It is believed, however, that it is spread by means of the fly I mentioned, one of the varieties of the tsetse fly, and the history is now being worked out. It has already been found that the tsetse fly exists wherever sleeping sickness is found, and it was recognised in this country by Mr. Austen, one of the members of the Malarial Commission, and is by no means uncommon in the Colony. Soon I hope we shall know, as definitely as we do in the case of the malarial parasite, how this one grows and multiplies.

FILARIA.

The next disease which I shall describe to you is caused by the **Filaria,** a little worm which gets into the blood and produces various diseases, and this worm is particularly interesting, because it is another parasite which requires the mosquito for its growth and propagation, as I shall be able to show you. It is the cause of a disease which is well known here, and which is much more common in some parts of the Protectorate than in Freetown. I refer to the disease called *Elephantiasis*. This is a disease which is characterised by tremendous enlargement of the legs, breasts, arms and other parts of the body, and it takes its name because the enlarged foot looks very like an elephant's. The disease is not fatal, but it is a very uncomfortable one, for sometimes the part gets so big that the person is unable to move about, and occasionally sores form on it, and the person becomes very feeble. When it gets like this the only remedy we know of, is to cut the affected part off.

The parasite was first discovered about forty years ago, but it is only lately that we have discovered that there are no less than half-a-dozen different kinds of filaria which affect the human being, but what the actual effect of these on the

human body is in all cases we do not yet know. In some cases they appear to do very little harm.

This is another disease which is very widespread, and it has now been found in nearly every tropical country, South Europe, India, China, America, and Africa. In Barbadoes it is so common that the disease is known in the West Indies as "Barbadoes leg." Some little time ago I devoted my attention specially to the prevalence of Filaria in this colony, and I examined everybody who came into the Colonial Hospital, and also got specimens sent down from the different stations in the Protectorate, and altogether I examined hundreds of cases. I found that out of every 100 people whom I examined no less than 21 had filaria in

FIG. 39.—**Filaria Nocturna and Filaria Perstans (double infection).**
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the blood. In some districts the percentage was much higher than this. For example, in Moyamba 38 out of every 100 and in Bandajuma 35 had filaria in their blood. Now those cases were not specially selected ; they were simply taken at random. So you see what a large number of people suffer from the parasite ; and though, as I have said, in many cases it does no harm, in a certain number of cases it produces various diseases. One of these I have already told you of, namely, *elephantiasis*, but there are others. It produces *swelling of the glands*, those that I have already told you of in the neck, and also those in the groin, and the latter sometimes grow to a large size ; it produces *swelling* of certain vessels

in the body called *lymphatics*, which is accompanied with swelling and pain in the legs, and fever; it also causes a disease called *Chyluria*, where the secretion from the kidneys, instead of being natural, is white like milk; and it also causes stoppage of those same vessels called lymphatics inside the body, where we are unable to get at them. It also produces *abscesses*.

I have told you that there are a large number of different kinds. The one which causes elephantiasis is a worm called **Filaria Nocturna,** one of which I now show you (Fig. 39). It is called Nocturna on account of a very curious habit which it has. We go to bed at night and get up during the day. *F. Nocturna* does exactly the opposite—it gets up

FIG. 40.—**Filaria Diurna, showing sheath.**
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during the night. If you take the blood from a person suffering from this parasite at twelve o'clock in the daytime, you will see nothing peculiar and no worms. If you look at six, you may find one or two; at ten, there are a few more; at twelve midnight, the blood will be swarming; at three, they have begun to lessen; at nine, there will be very few, and by twelve they have disappeared. Now it is believed that during the day all those little worms go into the inside of the body and hide themselves in the lungs and other organs. These worms are the *baby forms* or *embryos* of the parasite, and the parasites are to be found lying somewhere in the inside of the body. Well, the history of this parasite in the

blood is as follows :—The male and female get into the body in a way which I shall describe to you, and then they find their way into the lymphatics of the body. Then the female begins to breed, and those little embryos get loose in the blood and swim about freely. They do not attack the red blood cells as in Malaria nor eat them up, so that they do less harm in this way, but they do harm by blocking up the vessels which I spoke to you about and causing the glands to swell.

I have told you that there are other varieties of this worm, and before I go on to describe its development outside the body, I shall show you one or two of them. This, for example, is a specimen of **F. Diurna** (Fig. 40), and it is so called because its habits are exactly the opposite of Nocturna ; it is to be found in the blood by day and disappears at night. The second one which you see in Fig. 39, is another *F. perstan*, and you observe that this man had two different kinds of worms in his blood.

DEVELOPMENT OF FILARIA IN THE MOSQUITO.

Now we may proceed to study the development of this parasite *outside the body*. The little worm does not appear to

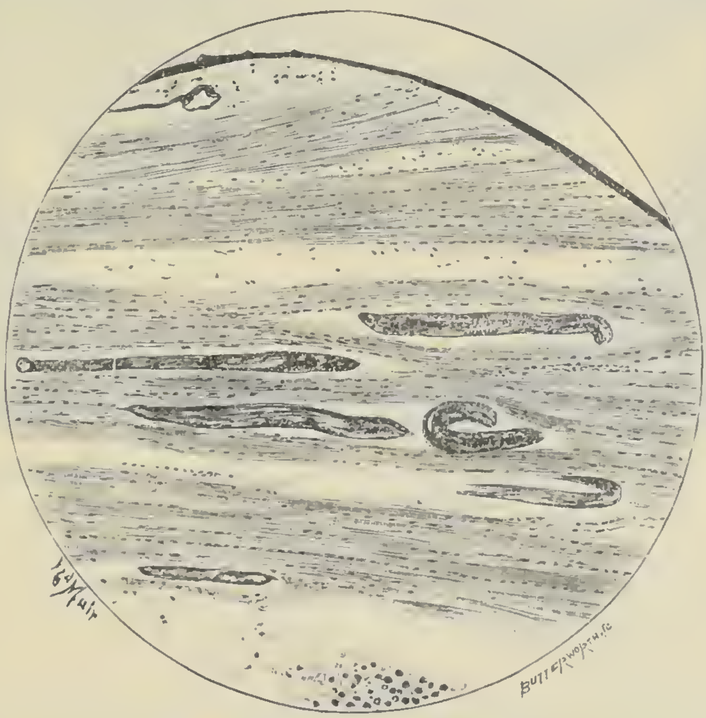


Fig. 41.—Section of thoracic muscles of Mosquito, showing filaria.

be able to grow up in the human body, it always remains a baby until it dies, so you can understand that when the mother dies those baby forms would gradually die out. And once more Nature steps in to prevent this, and again by means of

the mosquito. In this instance it is not the anopheles, but the **Culex**, which is the best carrier of the parasite. If you examine the body of a mosquito which has been feeding on a person who has got those embryos in his blood you will see a number of them swimming about. In a little while, however, they will all have disappeared, and if you examine the mosquito carefully you will find them lying among the muscles of the chest wall, as I show you here (Fig. 41.) About the fifteenth or sixteenth day they find their way to the end of the proboscis or trunk, and then you find them actually creeping along the sides of the trunk as is shown here (Fig. 42.)

FIG. 42.—**Filaria Nocturna in head and proboscis of Mosquito** *(aa)a)*.
By permission of the Publishers of TROPICAL DISEASES.

Now what happens when a mosquito who has got this parasite in its trunk bites you? The male and female gradually creep out of the trunk, get under the skin and finally work their way to the inside of the body, where they begin to breed the young baby forms I have shown you.

Now I need not go over all that I told you in my last lecture, for it must be quite evident that the only way to keep yourself free from this disease is by preventing mosquitoes from biting you, and the different methods have been very fully described to you. We are even worse off than in fever, for

we know no medicine which will kill the worm, and it affects everybody—children and grown-up, natives and Europeans. Once more I ask you, is it not worth while taking the simple precautions of which I have told you, in order to prevent yourself and your fellow-creatures getting these two diseases Malaria and Filariasis?

YELLOW FEVER.

But there is a third disease which is carried by the mosquito, and which is probably due to a parasite allied to Malaria, though up to the present we have not been able to isolate it. I refer to **Yellow Fever**. This disease is one which is not here at present, but we hear of it from time to time on the Gold Coast, Senegal, and on the Ivory Coast, and it is very common in South America, so there is no reason why it should not get into this place some day. It is a very dangerous disease, and it is especially fatal if it gets into a community where it has not existed before.

Although the germ has not been recognised under the microscope, there is one thing which we may regard as definitely proved, and that is, that it is communicated by the bite of a special mosquito, a mosquito which, unfortunately, is one of the most common in this city. It is called the **Stegomyia Fasciata**, and is one of those which have got striped legs. It has been proved in South America, by getting this special mosquito to bite people suffering from yellow fever, and then after a certain time to bite healthy people, with their consent, of course. It has been found that if these infected mosquitoes bite a healthy person within a short time after having bitten the infected individual nothing happens. It is evidently, then, not a purely mechanical infection, but the germ requires to grow, and it is found that after twelve days the mosquitoes become dangerous, and capable of giving the disease. It has also been proved that a mosquito retains the infection for at least fifty-seven days, so that you see that a ship coming from a yellow fever port might have infected mosquitoes on board, and these might get on shore. Quarantine would be no use in this case; and once we had the disease on shore, with plenty of these mosquitoes about, there could only be one result, and that is, a very serious and fatal outbreak of the disease.

Here, then, we find three diseases, three very serious diseases,—**Malaria, Elephantiasis, Yellow Fever**,—transmitted by varieties of mosquitoes, each of which exists here. Surely by this time you are convinced, and through you, I

hope the people of the town will be, of the necessity of taking the question of the extermination of mosquitoes seriously in hand.

INTESTINAL PARASITES.

We now leave the parasites which live and grow in the blood, and go on to consider those which affect other parts of the body, and first, of those which grow in the bowels, or as we call it, the Intestinal Canal.

TAPE WORM.

And the first which I shall tell you about are those which are known as **Tape Worms**. You have heard how certain parasites require two animals to complete their history, one the human being and the other the mosquito. Now we come to a group which also requires two animals, but in this case the higher animals, one being man and the other the cow, or the dog, and pig, and so on. There are several kinds of tape worm, and the full-grown stage of each lives in the intestinal canal; and though in some cases the parasite appears to do very little harm, in others it produces interference with digestion, convulsions, and other nervous diseases, headache, giddiness, and so on.

The life-history of this parasite is as follows: The mature worm gives off innumerable eggs, which pass out of the body by the excreta. The eggs get washed away by the rain into drinking water, or get dried and blown about by the wind. Then the next step is that they get swallowed by some animal, the cow or the pig. The next thing is that this egg bursts, and the young one comes out and bores its way through the walls of the stomach, and gradually finds its way into the flesh, or liver, or heart, or other part of the body. It then settles down in the places I have mentioned, a small bag forms round it, and it looks like a small white pea, which is called a "*cysticercus*." It may remain like this for a long time, but sometimes it happens that the cow or the pig is killed, and the meat is sold and eaten, and gets into the stomach of some human being. Then the head, which is very minute, fastens on to the bowel, and begins to grow longer and longer, until it forms a worm, sometimes several feet long. At the head it is very narrow and thin, and gets broader as it gets further away. Then eggs begin to come, and the whole process is repeated. I show you here the head of the pig tape worm, or *Tænia Solium*, as it is called. The

eggs grow in the pig and the full-grown worm in the human body. This head is shown very much enlarged, for the head is really only the size of a pin's head. Another one is the *Tænia Medio Canellata*, or the beef tape worm, the eggs growing in the cow and the full-grown worm in man. This is the most common form here, and for this reason, among others, the meat is inspected daily, and if the cysticercus is found is condemned.

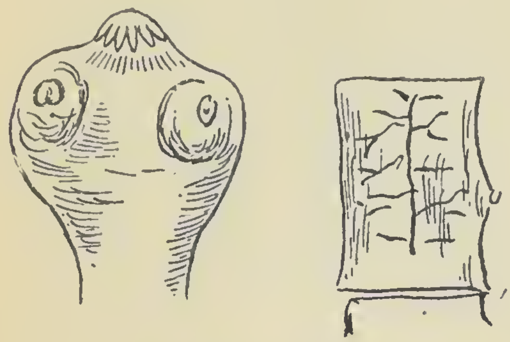


FIG. 43.—Head and Segment of Tænia Solium.

Another tape worm is known, the *Bothriocephalus Latus*, and grows as long as ten feet. In this case the eggs grow in fish and the full-grown worm in man.

In all of those which I have shown you, *the eggs develop in the lower animals, while the adults grow in man.*

But sometimes this position is reversed. There is a tape worm, the *Tænia Echinococcus*, the grown-up form of which grows in dogs, jackals and wolves, while the eggs are able to develop in man, and produce a very serious disease called "*hydatids.*" The egg is swallowed by man (sometimes by animals) and bores its way into the tissues, and finally settles in the liver or brain or other parts where it may produce very dangerous symptoms. These bodies sometimes grow to a very large size in the liver or brain, and very often cause death.

Now, how are we to avoid getting these parasites? Well, first of all the *meat* should always be *carefully examined*, and to do this it must be killed in proper places and sold in proper markets where it can be inspected. Meat should always be *properly cooked*, for cooking destroys the cysticercus. In order to avoid getting the eggs into our body, we should see that our *water supply is pure* and protected from contamination, and as the eggs can be blown about in dirt, we should try to prevent dirt being carried about as much as possible by *having the streets watered.* Then, when we eat salad or *vegetables* we should see that they are *properly washed* in clean water, for as vegetables are generally grown in well-manured ground, they can readily become contaminated with eggs.

ROUND WORM.

The next parasite is one which is very common here, the **Round Worm.** They are specially common in children, but are also very often found in adults in this country, and sometimes may be seen in large numbers, dozens or even

hundreds. It is a common, round, red worm, just like the ordinary earth worm.

The life history of these worms is much simpler. The egg gets out into the world by the excreta, and is then blown about until it reaches a suitable place. It requires a certain amount of moisture and heat, and the little worm can be seen developing inside the egg. If, when this development has taken place, it is swallowed, the outside shell is dissolved by the stomach juice, and the worm begins to grow into the mature worm. It may get admittance to the body by *drinking water*, or it gets attached to *fruit* or *vegetables* and is thus eaten. Probably one of the reasons it is so common in this place is the habit market women have of placing fruit and vegetables on the ground for sale, so that they get easily contaminated.

It is not, as a rule, a serious disease, but it may give rise to internal troubles, indigestion, pains in the belly and so on. Occasionally they may cause epileptic fits, or may get into the passages leading from the liver, block them up, and cause jaundice.

Here, again, we must pay the greatest attention to the *cleanliness of our vegetables* and the *purity of our drinking water*.

THREAD WORM.

The next parasite is what is called the **Thread Worm,** and is most commonly found in children, though it infects people of every age. It inhabits the lower part of the bowel, and the irritation of its presence causes itching, restlessness, loss of sleep, and considerable enfeeblement. The female is about one-third of an inch long and the male a little smaller—about one-sixth of an inch. A person gets infected by swallowing the eggs, which get into the water or on vegetables, or children who have the disease scratch themselves and the eggs get underneath the nails, and then they re-infect themselves.

ANKYLOSTOMA.

Our next parasite is one which has got a very big name —**Ankylostoma**—but it is a very important one, as it gives rise to a very serious disease, and it exists on the West Coast of Africa, and is very common in Freetown. It is a small worm about half an inch long (Fig. 44), and it lives in a part of the bowel close to the stomach called the duodenum. There it, fixes itself on to the lining of the bowel by its mouth, which has got four strong little hooks for this purpose. It then proceeds to *suck the blood*, which is its food. You can understand that if

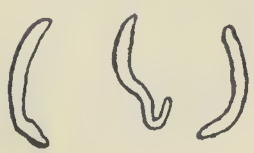


FIG. 44.—Ankylostoma.

a person has a large number of these animals sucking his blood he soon gets weak, pale and bloodless, and, in consequence, the face and feet swell owing to the poorness of the blood. Death then takes place from exhaustion if the disease is not properly treated.

The female ankylostoma keeps laying eggs, which pass out of the bowel with the excreta. The eggs then hatch out and finally turn into a small worm, which lives in damp ground or mud. It may then get into the human stomach on the hands, or by drinking muddy water, and gives rise to the serious disease which I have briefly described to you. In this country, where spoons are very often not used, and where a considerable number of people eat with their fingers, it is not difficult to .understand how easily the young of these parasites can be transferred to the stomach after having got on to the hands when working.

There is another way in which it can get into the body, and that is simply by boring through the skin of the hands or feet. The way to avoid getting this is, again, *cleanliness.* See that children's hands are washed before they are allowed to take food, and *be careful how the excreta are disposed of.*

TRICHINA.

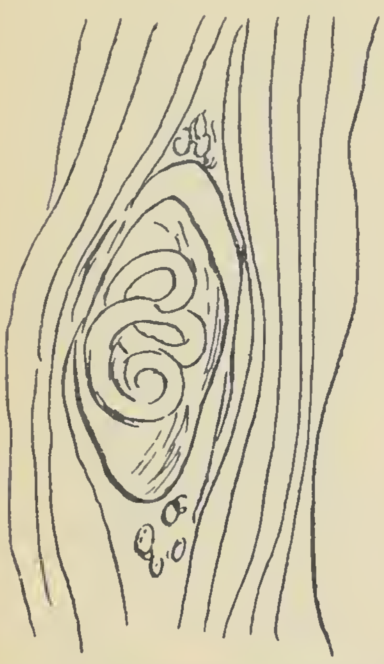


FIG. 45.—Trichina in human muscle (Leukhardt).

We now leave the intestinal parasites and come to a consideration of others which affect different parts of the body. And first **Trichina.** This parasite, though it gets in by the stomach, really has its home in the flesh or muscles. In this case man gets infected by eating pork or sausages which have not been properly cooked. The mature or full-grown worm inhabits the bowels, and there the female gives off its eggs, which develop into thread-like bodies. These find their way through the walls of the intestines, and eventually get into the muscles. I show you here a specimen of the trichina after it has reached the muscle (Fig 45). If a man eats pork containing this parasite it develops in his interior in exactly the way which I have described, and, while the worms are boring their way through the tissues, they cause very serious symptoms. There is great pain, fever,

disturbance of the stomach, inflammation of the muscles, swelling of the legs and arms and face, and sometimes the patient dies from exhaustion. If he lives until these little worms have found their way into the muscle he may recover completely, as a little lining of hard flesh gradually forms round them, and they do no further harm.

In order to prevent these getting into our bodies it is essential that we should see that all *pork and sausages are thoroughly well cooked*, so as to kill the young trichinæ. In countries where quantities of half-cooked ham and sausage are eaten—as in Germany—this disease is much more common.

FLUKES.

The next parasites which I shall mention to you are what are known as "**Flukes,**" the scientific name being Distoma. The word fluke means anything flat, and one of the commonest forms—the liver fluke—is flat, but others are not. The life history of the flukes is very interesting. The mature fluke lives inside the body of its host, who may be a man or some other animal, and while there its eggs are expelled from the intestines in the excrement. This is washed by the rain, or, if it dries, carried by wind, until the eggs reach water, when they turn into little embryos, which have a lot of little threads or "cilia" along the edge, and are then able to swim about. After a few days they lose the threads or "cilia" and become a small, crawling animal, which gets into the inside of a kind of water snail, where it undergoes further development and forms other young ones. These young ones now get out into the water again and are swallowed by man. They then get into the liver and bowels and begin to grow into the mature fluke. So that we see the history to be as follows: Man, water, fresh-water animal, water, and then man again.

The liver fluke is a very serious parasite to have, and produces enlargement of the liver, diarrhœa, indigestion, headache, and the person grows thinner and thinner. I am not sure whether it exists here, but if it does, it is not common, for I have never seen a case.

Another fluke is known as the Blood Fluke (*Bilharzia Hæmotobia*), and was discovered over fifty years ago in Egypt. It is found in several parts of the world, and exists here. In human beings it inhabits the veins in the belly, especially those connected with the liver and kidney, and when in the latter organ, gives rise to blood in the urine. The eggs, which can be found in the urine, are oval, with a small spike at the end. When they get into water—like the liver fluke—they

are soon able to swim about, but their after history has not yet been traced. There is little doubt, however, that it is the same as the liver fluke, and that it *gains entrance into the human body by means of drinking water.* One or two cases have been described on the West Coast of Africa, and it is a very serious disease, as the bleeding causes the person to become bloodless and thin. One of my medical officers found a case of this disease in the Protectorate.

There are other parasites which attack the inside of the human body, but they are very rare, and it is unnecessary for me to describe them to you.

GUINEA WORM.

The next parasite is one which is familiar to most of you, if not by sight at any rate by name, the **Guinea Worm**. It is a disease of Africa, and Arabia, and India. It is much more common on the Gold Coast than it is here; in fact, when I was there, I used to see ten or twenty cases every morning among the Haussa soldiers. It is very rare in Freetown. The freedom from guinea worm I attribute to the better water supply we have here.

Fig. 46.—**Adult Guinea Worm, female.** (Leukhardt).

The female guinea worm, after its entrance into the body by the stomach, as I shall show you presently, gradually finds its way until it lies somewhere near the skin of the leg or foot. There she produces a swelling, and finally, a small blister forms, and a hole is seen in the centre. If we look carefully at this we can very often see the head of the worm. I show you here a picture of the female guinea worm (Fig. 46), and you will see that the tail forms a hook, so that the worm can keep its hold. Now if we take some water and drop it gently on the small opening, we shall see a little milky fluid come out of the hole, and if we examine this with a

microscope we find numbers of coiled-up guinea worms (Fig. 47). If we put these in a water glass they uncoil themselves, and swim about freely. The mother guinea worm is constantly doing this, and if the babies happen to get into a stream they are ready for the next stage, which is that they find their way into the interior of a little water insect, where they undergo a change, and lose their tails. Then, when people drink dirty water, these little insects get swallowed, and the parasite is liberated, and gradually develops and finds its way under the skin, and begins over again.

FIG. 47.—Embryos of Guinea Worm.

There are of course two things to do. The first is to see that you only *drink pure water*, and if you are travelling you should boil it or use a pocket filter. The second thing is that if any one has guinea worms he should see that *none of the baby worms get into water, and thus spread the disease.* If guinea worm is not properly looked after it may cause great swelling and abscesses and ulcers, and even make a person lame for life.

JIGGER.

We are getting near the end of our parasites, and the next one to consider is an old friend, the **Jigger** or **Chigoe** as it is called in some places. Now, most of you look upon this as a very trifling disease, but in some parts of the world it causes a great deal of sickness, and produces swelling of the legs, inflammation, ulceration, and even total loss of the limb. This happens especially when it gets into a new community which is not accustomed to it, and on the East Coast of Africa it is causing a great deal of sickness among the Indian coolies, who have frequently to be sent home on account of it.

The jigger is very like a common flea, and lives in sandy soil, dirt, ashes, and so on. The female finds its way under the skin, generally of the toes, because those are more likely to be on the ground, by burrowing under the skin, but I have seen it in the finger and elsewhere. Then she begins to swell, and her belly gets full of eggs. Generally by this time you wonder what is irritating your toe, and when you look you find a swelling with a black dot in the centre. If the jigger is not taken out, as soon as the eggs are ripe, they fall out on the ground, where they form small larvæ, which in time develop into small fleas.

I need hardly tell you what to do when you get a jigger. The best thing is to *take it out with a clean needle*, and try not to burst the bag while doing so. *Avoid walking barefoot* as much as possible, and *keep the floors* of your houses and yards very *well swept*. Be especially careful to get rid of accumu-a tions of ashes, dust, or stable or poultry refuse.

TUMBU.

Another animal parasite here is what you call, I believe, "**Tumbu.**" This fly lays an egg on the skin, and then the larvæ bores its way under the skin, and what looks like a very painful boil forms. If you look at the centre of this, you will see the head of a maggot moving, which can be pulled out with a pair of forceps. If you put the maggot in a box with a little cotton wool it dries up, forms what is called a "cocoon," a little oval body, and after lying like this for a little while it turns into a fly.

I am inclined to believe that the fly sometimes lays the eggs on underclothing when laid on the ground to dry, but sometimes they may be laid directly in the skin at night. The best way, then, to prevent them is to protect yourself while asleep by using a mosquito net and keeping the body covered.

Craw-Craw.

The last parasite which I shall mention, is the one which causes **Craw-Craw,** a disease which breaks out in the skin, and especially the hands, and causes great itching and discomfort. There are several different varieties of this disease, but all of them are due to *want of cleanliness*. Some are caused by germs such as you saw in the first two lectures, getting into the skin and growing there, while another is due to a small insect like a very small crab, which burrows under the skin, making long tunnels, and laying its eggs as it goes along. This causes great irritation, and small boils form. Fortunately it can be very easily cured by *rubbing sulphur ointment* on the sore places. This stops up the hole, and the insect is suffocated.

Now, as I have already told you, these skin diseases are due to the habit washerwomen have of placing the clothes to dry on the ground, and also to the water the clothes are washed in. At Kissy you will see a whole number of washerwomen one above the other, and you will understand that if a washerwoman is washing clothes infected with a skin disease, the germs will get carried down and infect the clothes of those

washing below, especially if the water is low, as happens during the dry season. Now that there is a plentiful water supply, the question of *providing proper public washhouses* is one which ought to be seriously taken up, so that, not only would the same water not be used again and again, but the clothes would be hung up on ropes to dry.

Now we have come to the end of this part of our subject; we have considered parasites of all kinds, vegetable and animal. I have given you a terrible list of diseases to which they give rise, diseases which in my first lecture I described to you as *preventable*, and I trust I have been able to show you how these diseases may be dealt with and prevented. I do not wish you to try to burden your memory with all the long names which I have had to mention for purposes of description; I wish you to remember the general effects of the parasites and the principles by which you are to be governed in dealing with them, and it may be as well now to briefly go over some of the lessons we have learnt, to impress them upon you once more, and to endeavour to arrange them in a systematic way.

And the first thing I have impressed upon you is the necessity of **Cleanliness**; cleanliness in your person, in your clothes, in your houses, in your yards, in the food, and in the water you drink. I keep telling you this, because through you I hope to reach the vast uneducated mass of this community, and to find in you a number of enthusiastic missionaries who will spread about in the land a knowledge of the gospel of "Cleanliness."

We have learnt then—

1. That **cleanliness of the body and clothes** will do away with diseases such as boils, yaws, leprosy, skin disease.
2. That **plenty of sunlight** and **fresh air** will prevent the spread of diseases such as consumption.
3. That attention to the **cleanliness of the yards** will prevent such diseases as lockjaw, plague, etc., and in this connection the danger of rats was pointed out.
4. That attention to keeping the **water good and pure** will prevent cholera, typhoid, and so on.
5. We have learnt that **keeping the body in a good state of health** will prevent germs and animal parasites from growing in it.
6. That certain diseases can be **carried by food,** and that everything should be clean, and that food requires to be properly cooked.
7. That there are such things as **infectious diseases,** and

that these require special measures such as Isolation, Notification, Vaccination, etc.

8. That three very serious diseases—Malaria, Elephantiasis, and Yellow Fever—are **carried by mosquitoes,** that the way to prevent them is to *avoid being bitten*, and that we should aim at the total *destruction of mosquitoes.* We learned a very important fact in this connection, namely, that children die in large numbers from malaria.
9. We have learned that some diseases, caused both by animal and vegetable parasites, are **spread by dust,** and that this should be diminished by watering the streets and your yards.
10. The **dangers of the present system of washing clothes** have been pointed out to you: and
11. That the **keeping of excreta in cesspits** is a very dangerous one, and apt to favour the growth of disease germs.

These are very important lessons, and it is only by the individual efforts of each one of you that they can bear practical effect. I do not want you to go away from here and forget them. I wish you, when you see anything insanitary, to try to remedy it, and if you are unable to do so yourselves, I count upon you to assist me by drawing my attention to it.

LESSON IX.

THE DIGESTIVE SYSTEM.

The next subject which we shall proceed to study is a very important one, namely **Food,** and, before doing so, it will be convenient at this stage that we should learn something of the mechanism by which food is received into, and dealt with by, the human body, that is to say, the structure and functions of

THE DIGESTIVE SYSTEM.

The **Mouth** is the first portion of the digestive canal, and contains the **tongue** and the **teeth,** and also receives the secretion of the salivary glands, the **saliva.**

Teeth.

When a baby is born, it has no teeth, showing that its food should be of such a nature as not to require chewing, that is to say, it must be liquid ; and nature provides the best food in the form of milk.

About the sixth month, the first set of teeth, the temporary or **milk teeth** appear. They are twenty in number, the last appearing during the third year.

The **permanent teeth** are thirty-two in number, sixteen in each jaw, and they begin to appear about the seventh year, when the temporary teeth commence to drop out. By the fourteenth year, all the permanent teeth have appeared, with the exception of four at the back, called the **wisdom teeth,** and these are sometimes delayed until the twenty-fifth year.

A tooth consists of hard material, the outside of which is called **enamel,** and is harder than bone, and a hollow containing a **pulpy substance** consisting of nerves and blood vessels. When the hard part of a tooth is worn away, and the pulp is exposed and becomes inflamed, we have that very painful affection known as **toothache.**

The teeth are of different shapes and sizes, according to the use to which they are put. In the front we have the

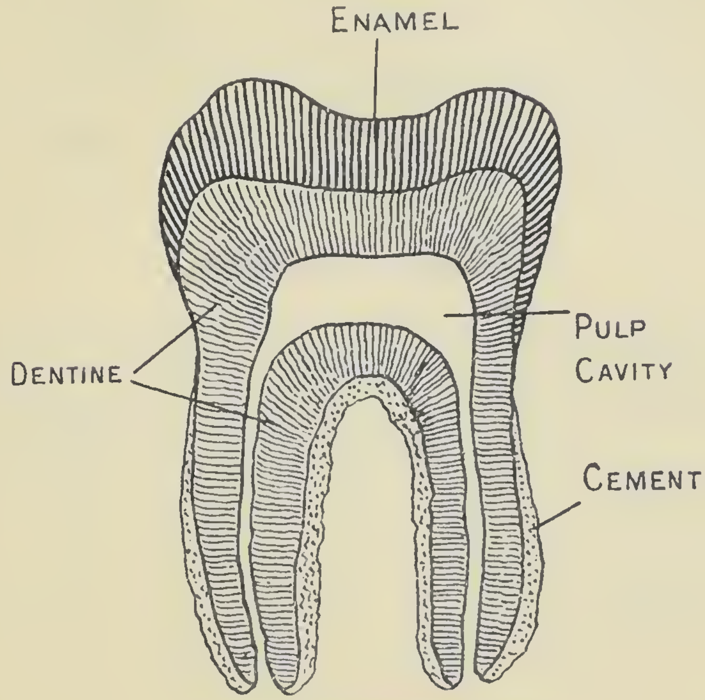


FIG. 48.—Section of tooth.

Incisors, used for biting, and at the back the **Molars,** for grinding up the food. By this means the food is formed into a pulp, and mixed with the saliva, by which means it is placed in a condition to be more readily digested. It is very important, therefore, that *all food should be well chewed*, and not swallowed in lumps, otherwise a much greater strain is thrown on the stomach.

The *first* step in digestion, then, is **chewing** or **mastication.**

The Salivary Glands.

There are three pairs of these, and they are placed as follows: One pair in front and below each ear, one below each side of the lower jaw, and another pair under the tongue. From each gland a little tube or pipe leads into the mouth, and along these the saliva or spittle slowly trickles.

The **Saliva** is a thin fluid, and consists of water, salts, mucus, and a special digestive substance called **ptyalin.**

The action of the saliva is to **moisten the food** and thus assist mastication, and in addition, the substance called ptyalin **acts on starch,** and turns it into a special kind of sugar, in which form it can be absorbed in the stomach. You will learn directly what the starchy foods are, and as they form

the greater part of the food in this country, the necessity of chewing the food well, so as to thoroughly mix it with the saliva, is again shown. I know that in this country it is the practice to swallow "foofoo" in lumps, which probably accounts to some extent for the considerable amount of indigestion which is to be found.

The *second* step in digestion is, then, **Insalivation,** or transformation of starch into sugar.

The Œsophagus.

Having been well chewed and mixed with saliva, the tongue gathers the food up into a mass, carries it to the back of the mouth, where it is forced into the **Gullet** or **Œsophagus.** This is called **swallowing** or **deglutition.**

The **Gullet** is a soft fleshy tube about nine inches long, and extends from the back of the mouth, passing downwards along the backbone and through the diaphragm to the opening of the stomach (Fig. 50). When no food is passing down it, the walls lie close together. No digestion takes place in the gullet, but the inside of the tube is kept moist by a secretion of mucus, so that the passage of the food is rendered more easy.

The Stomach.

The food now reaches the **stomach,** the principal organ of digestion (Fig. 50). It is a large bag lying more to the left than the right side of the belly, just under the diaphragm. The part into which the gullet opens is called the **cardiac** (heart) end; and the one opening into the bowel, the **pyloric** end. The stomach well is composed of three layers, outside, the **peritoneum** or membrane lining the whole of the abdomen and bowels, then a strong **muscular** layer, and inside, what is known as the **mucous membrane.** On examining the surface of the mucous membrane with a strong magnifying glass, a number of small pits are to be seen. These are the openings of the **gastric** or **peptic**

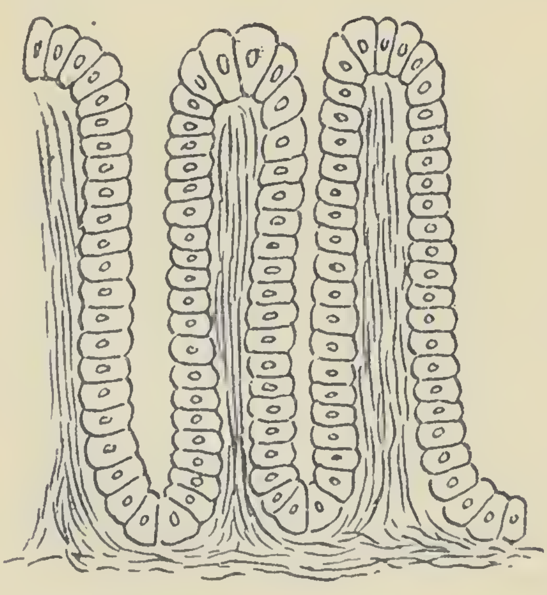


FIG. 49.—Peptic Glands of stomach.

glands, formed of small tubes or pipes with closed rounded ends, and packed very closely together (Fig. 49).

Round the tubes is connective tissue in which lie a large number of blood vessels and lymphatics.

The glands secrete the **gastric juice,** a clear, colourless *acid* liquid, which contains water, salts, hydrochloric acid, and a special ferment called **pepsin**. I may tell you here that a **ferment** is a *substance which has the power of changing certain substances into others.* For example, yeast has the power of changing sugar into alcohol or spirit. When palm wine is drawn from the tree you know that it is quiet sweet, but that after keeping it becomes strong, and little bubbles of air form in it, and if people drink too much *old* palm wine they become intoxicated. That is because yeast has turned the sugar of the palm wine into spirit. We have already seen an example of one ferment in the saliva, namely, ptyalin. Well, the gastric juice has the power of turning certain parts of the food called **proteids,** which are insoluble, into **peptones,** which are soluble, and can pass through the stomach wall.

When food reaches the stomach, the first effect is that the *acid stops the action of the ptyalin*, so that starchy matter is no longer acted on. The pepsin, together with the hydrochloric acid, then *acts on the proteids*, *converting them into soluble peptones.* The gastric juice has no action on oils or fats, or on what I shall describe to you later on as carbo-hydrates, that is starches and sugars.

All this time the muscular walls of the stomach are contracting, and the food is being moved round and round, getting well mixed up with the gastric juice, and loosening all the small particles of fat, until at last a kind of greyish creamy fluid called **Chyme** is produced. Meanwhile the soluble peptones are being rapidly absorbed directly into the network of blood vessels in the stomach wall.

Lastly, after a little time, varying from three to four hours, the chyme passes through the pylorus into the first part of the bowels, namely, the duodenum.

The *third* step in digestion, then, is **peptic digestion,** that is, the conversion of proteids into peptones by pepsin, and the changing of the stomach contents into chyme.

The Small Intestine.

The stomach opens directly into the **small intestine** or bowel (Fig. 50), the upper part of which is called the **duodenum.** The whole length of the small intestine is about 21 feet. At the lower end it opens into the large intestine.

Like the stomach it has three coats outside, peritoneum, intermediate, muscular, and inside, mucous membrane.

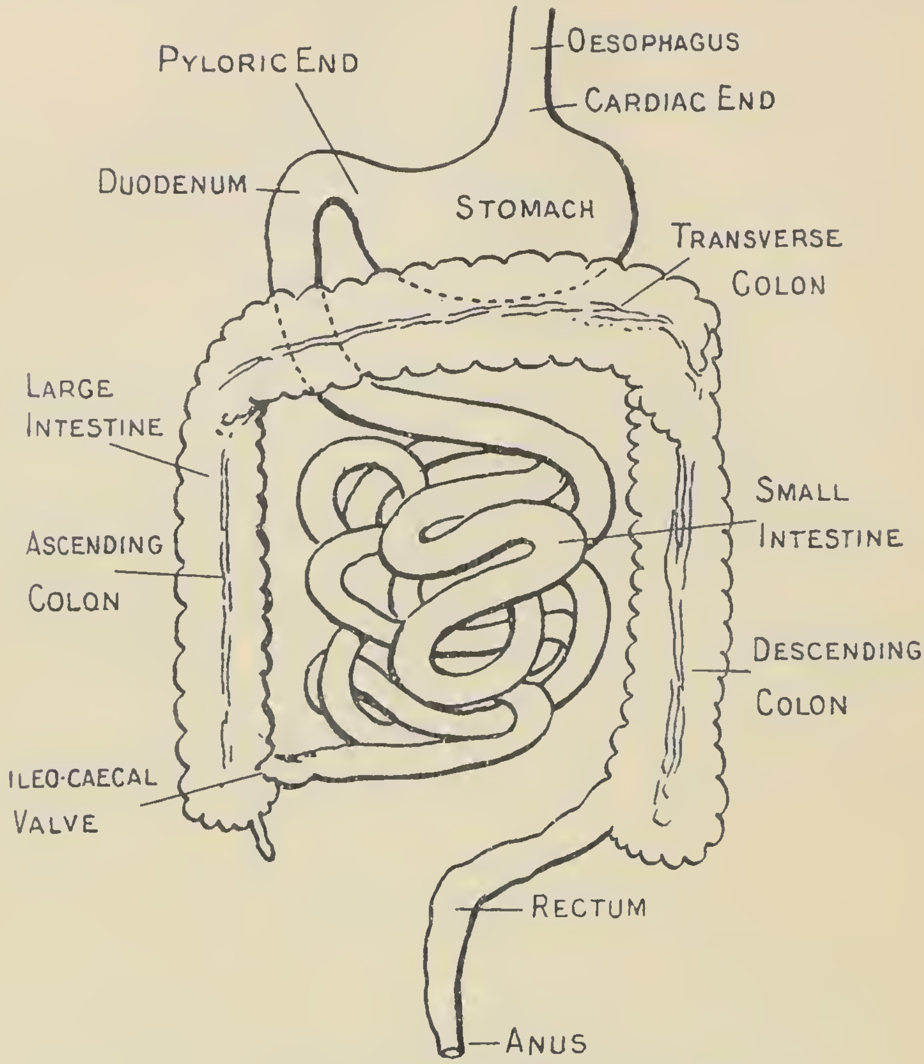


Fig. 50.—Diagram of stomach and intestines.

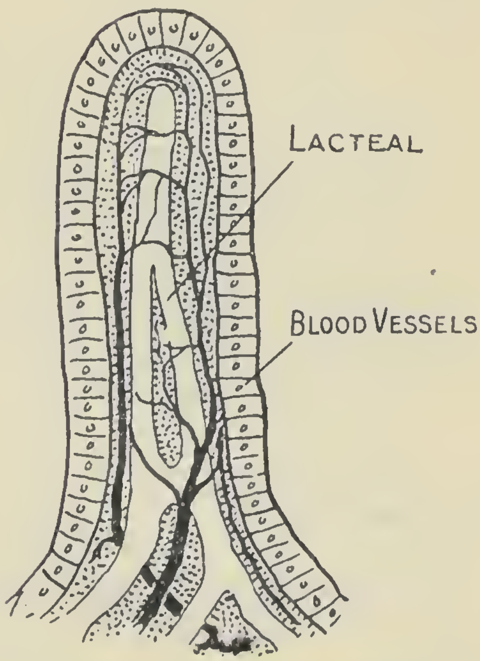


Fig. 51.—Villus, highly magnified.

The latter is thrown up into a number of large folds, **valvulæ conniventes,** which greatly increase the surface area. If we examine the surface with a magnifying glass, as we did the stomach, we notice that it is thrown up into a number of minute projections like the finger of a glove, which gives it a fine velvety appearance. These are called **Villi** (Fig. 51). They consist of a layer of

column-shaped cells, in the middle of which will be found an artery, a vein, and an irregularly shaped vessel called a **lacteal.** This lacteal opens into the lymphatic vessels running underneath the mucous membrane. The villus is a very important structure, as we shall see presently.

Between the villi lie a number of single tubular glands which secrete the intestinal juice.

The Large Intestine.

The large intestine is about six feet in length. The small intestine opens into it just above the right groin, at what is known as the **ileo-cæcal valve** (Fig. 50), which allows the food to pass forwards but not backwards. It then goes upward to the under surface of the liver, the **Ascending Colon,** across to the left side, the **Transverse Colon,** and then downwards along the left side, the **Descending Colon.** The last part of the intestinal canal is the **Rectum,** which opens externally at the **Anus.**

The Liver.

Before we study what happens when the food leaves the stomach, there are two organs connected with digestion which I must describe to you. The first of these is the **Liver.** This is the largest gland in the body, and weighs from three to four pounds. It is situated just under the diaphragm, more to the right than the left side, and is divided on the under side by a cleft into a right and left lobe, the former being much the larger of the two. At this cleft three vessels may be seen, the **Hepatic Artery,** carrying blood from that big vessel, the aorta, to the substance of the liver; the **Hepatic Vein,** collecting blood from the stomach, bowels, pancreas, and spleen; and the **Bile Duct,** carrying bile manufactured in the liver to the upper part of the small intestine. Leading from the bile duct is a small tube opening into the **Gall Bladder,** in which bile is stored until it is required. The gall bladder lies on the under surface of the liver to the front.

The substance of the liver consists of a number of lobules, which are composed of small cells with blood vessels and small bile ducts lying between. The cells manufacture bile from the blood, and this is discharged into the small bile ducts, which in their turn open into larger tubes, and so on until the large bile duct is reached.

The **Bile** is a yellowish fluid consisting of water, mucus, and special salts called **bile salts.** There is also some colouring matter. Bile acts on the fat in the food in the intestine and emulsifies it. Let me explain to you what **emulsifying** is. If you mix a little oil and water together, the oil breaks up into small drops or globules, but when you stop shaking, the oil runs together again. But if you add a little soda and shake the oil and water up, it becomes quite milky, and the drops are seen to be very small, and they may be allowed to stand for some time without the oil running together again. This process is called *emulsification*, and the bile has a similar effect on the fat in the food. In addition, the bile is *antiseptic*, and acts a *stimulant* to the bowels.

The liver has two principal functions :

1st. To **secrete bile** and
2nd. To **store up** a substance called **Glycogen,** which it manufactures out of the sugar contained in the food. It can turn this Glycogen back into sugar when the body requires it.

The Pancreas.

The other secreting organ is the **Pancreas** or Sweetbread. It is a reddish yellow gland running across the back of the abdomen behind the stomach, from the duodenum to the spleen, and is about seven inches long. It consists of a number of rounded tubules lined with cells which secrete the **Pancreatic Juice.** This is discharged into the duodenum by the Pancreatic duct which enters at the same place as the bile duct.

The **Pancreatic Juice** is a clear fluid, composed of water, salts and ferments. The salt is principally carbonate of soda, so that this juice is *alkaline*, in contradistinction to the gastric juice, which you remember was very *acid.*

The **ferments** are three in number :—

(*a.*) One **acting on starch,** in the same way as ptyalin, turning it into grape sugar.

(*b.*) One **acting on proteids,** (called **trypsin**) convert-them into soluble peptones, just like pepsin, but with this difference, that it is stronger and acts as an alkaline, and not an acid solution.

(*c.*) One **breaking down fat,** and along with the bile emulsifying it.

The pancreatic juice then completes the work left undone by the saliva and the gastric juice.

Intestinal Digestion.

Now, let us see what happens when the food reaches the duodenum. It is then in the form of chyme. The first effect is, that the acid is neutralised by the soda, and the action of the pepsin is put a stop to. Then the pancreatic ferments act on the proteids and starch remaining, and convert them into peptones and grape sugar, which are absorbed directly into the blood vessels, and carried by the portal vein to the liver. At the same time emulsification is going on, the fats are being broken up, and the acid chyme is eventually changed into an alkaline creamy fluid known as **Chyle.** This is too thick to be absorbed directly into the blood like peptones—what happens to it? Here the villi step in. The chyle finds its way through the cells covering the villi into the irregular shaped vessel—the lacteal, from that into the lymphatics, and finally enters directly into the blood stream.

Meanwhile, the muscles in the wall of the bowel are slowly contracting, first those in the upper part, and then those below, causing what is called **peristaltic contraction,** mixing the food up and gradually moving it along the twenty-one feet of intestine, until it reaches and passes through the ileo-cæcal valve into the large intestine. By this time most of the liquid has been absorbed, and it is now semi-solid, and in its further course along the large intestine, all remaining useful material is absorbed, the indigestible matter reaches the rectum in a solid form, and is excreted through the anus as **fæces.**

The *fourth* step in digestion is then a somewhat complicated one, and consists

(*a.*) In **Tryptic digestion**, whereby proteids are converted into peptones.

(*b.*) In **transformation of starch into grape sugar.**

(*c.*) **Emulsification** and **absorption of fat.**

(*d.*) **Absorption of soluble material along the whole length of the intestinal canal.**

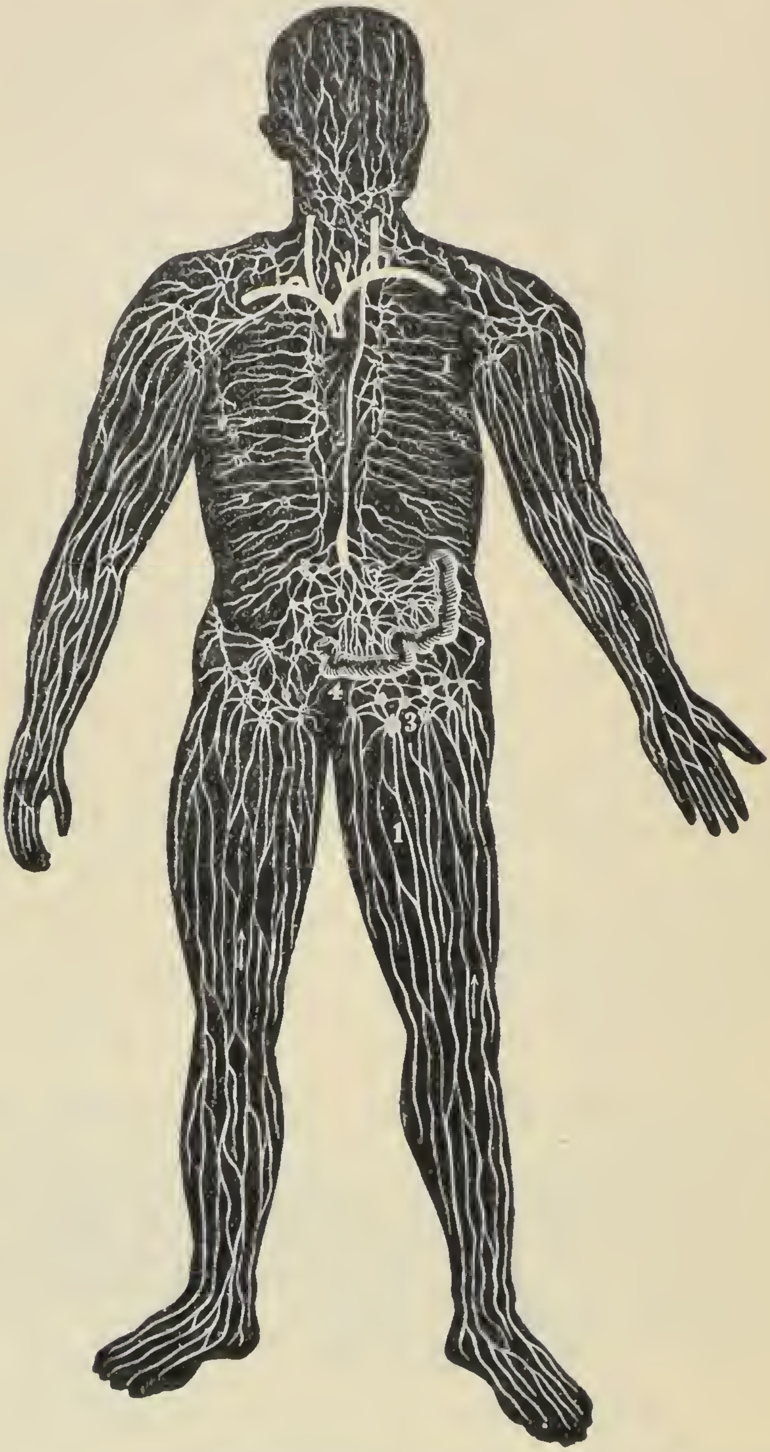
The *Final* step is **Excretion.**

THE LYMPHATIC SYSTEM.

On more than one occasion I have had to refer to vessels called lymphatics, and you have learned that the lacteals open into small lymphatics. These in turn open into a large vessel called the Thoracic duct (Fig. 52), which lies along the backbone, and enters a large vein at the root of the neck, so that

some of the changed food eventually gets right into the blood.

But all over the body there are a number of fine vessels called **Lymphatic Capillaries**, which lie between the various



Above Illustration by kind permission of Messrs. Longmans & Co.

FIG. 52.—**The Absorptive System—general diagrammatic view.**

structures. Here and there along their course we find swellings, as for example, in the elbow, and armpit, which are called **Lymphatic glands.** Eventually they too open into the thoracic duct.

The lymphatics, with the exception of those leading from the lacteals, which you remember contain chyle, are filled with a clear fluid called **Lymph**. This is formed out of the fluid which exudes through the walls of the small blood vessels, and contains matter which is capable of being used again. As the lymph passes through the lymph glands, it becomes more and more like blood in composition, so that we may regard the lymph glands as being partly concerned in the manufacture of the blood.

The **Spleen** is generally considered as belonging to this system. It is a dark purple organ about six inches in length situated under the ribs on the left side of the body just at the cardiac end of the stomach.

Its functions are to manufacture new white corpuscles, and to get rid of worn out red corpuscles. It is thus a very important organ in this country, where the blood is constantly being destroyed in malaria, and, as a matter of fact we find, that the spleen becomes very much enlarged, especially in children.

LESSON X.

FOOD.

To-day we go on to consider a very important subject, namely, **Food.** Now, although all of us know the necessity for food, and the unpleasantness of being hungry, and recognise that if we wish to live we must eat, yet I suppose there are very few who really take the trouble to think *why* we require food. Let us go back for a moment to our comparison of the human body to a steam engine. The boiler is filled with water and all the parts are properly oiled, but the steam engine does not move until a fire is lighted under the boiler. Then steam is produced, and the engine moves. In other words, fuel is required for the *production of energy*. So it is with the human body. Energy is produced by the burning up or what is called *oxidation* of different parts of the body, and food supplies the material for the burning up. But having once started the steam engine, we find that the coal in the furnace gets consumed, and the steam engine gradually stops. We must therefore replace the coal that is burnt with fresh coal. In the same way we have constantly to *repair the daily waste* that is going on in the human body. Further, during a certain period of life, during infancy, youth and early manhood, the body is increasing in size, and food is required to *provide the material for this growth*.

Lastly, food is the means of *keeping up the temperature of the body*. During life, when oxidation is going on, the body remains at a temperature of a little over 98 degrees, and some of you know that when you are ill a doctor puts a small thermometer in your mouth or in your armpit and takes your temperature. As he knows what the proper temperature of the body is he can tell by means of this whether you are well or ill.

In cold countries if there were not some means of keeping the temperature up, of giving more fuel to the body, the individual would get colder and colder and die. The same would happen here, but more slowly, and, as you know, after death the body gradually loses its heat and becomes cold.

We see, then, that food is required for four things :—

1. **The production of energy,** viz., work.
2. **The repair of waste**
3. **The building up of new tissues** or materials.
4. **The production of heat,**

and we must study what kinds of food will best promote these requirements, and how they are to be combined and regulated.

THE COMPOSITION OF THE BODY.

We have seen that the human body is built up of different systems and organs, and now I have to add that these in their turn are composed of **chemical compounds,** that is to say, of the **elements** of matter joined together to form various complicated substances.

A very large part of it, two-thirds by weight, is composed of **water,** a combination of Hydrogen and Oxygen, which serves the purpose of rendering the tissues soft, and also distributes nutrient matter. The remaining third consists of the chemical elements to which I have referred, the most important of them being **Oxygen, Hydrogen, Nitrogen, Carbon, Sulphur,** and **Phosphorus.** Of these the first three are gases in their natural state, and the last solid ; and when they are combined in the human body they form substances known as **organic compounds.**

These compounds are generally classified into non-nitrogenous and nitrogenous.

Non-nitrogenous compounds contain Carbon, Hydrogen, and Oxygen only, and consists chiefly of the **fats** and **amyloids.**

The **fats** or oils of the body are known as **hydro-carbons,** while the **amyloid** substances are called **carbo-hydrates,** and are found in the glycogen which we have learned may be stored up in the liver.

The **Nitrogenous** compounds are what is known as **proteids,** extremely complex substances made up of Nitrogen, Oxygen, Hydrogen, Carbon and sometimes a little sulphur and phosphorus. The principal of these are **albumen,** a substance resembling the white of egg, found in the blood and tissues ; **myosin** forming the muscle or flesh ; **gelatine** in the bones ; **fibrin** in the blood, etc.

Then there is **mineral matter,** consisting of various salts ; chloride of sodium or common salt, which is distributed throughout the body, carbonate of lime and phosphate of lime in the bones, iron in the blood and others.

The proportion in which these different compounds form part of the body is as follows :—

Water ...	... 61·0	per cent.
Proteids ...	... 18·0	,,
Carbo-hydrates	... 0·1	,,
Fats ...	... 15·4	,,
Mineral salts	... 5·5	,,

It is obvious, then, that as these materials are used up in our daily life, they must be replaced by similar substances, and consequently the food has to be selected with this end in view. To do this we must know in what proportion the elements of the body are used up, and for this purpose very careful experiments have been made. It has been found that during average work, the human body uses 4,500 grains of carbon, and 300 grains of nitrogen daily, which, as I shall show you, are the two most important constituents of our food.

The daily loss is shown in the following table :—

	Water.	Carbon.	Nitrogen.	Hydrogen.	Oxygen
By the Lungs ...	·330	248·8	—	—	651·15
" Skin	·660	2·6	—	—	7·20
" Kidneys ...	1·700	9·8	15·8	3·3	11·10
" Dejecta ...	·128	20·0	3·0	3·0	12·00
Grammes	2·818	281·2	18·8	6·3	681·45
Grains, nearly ...	...	4,500	300		

In order that we should understand how this loss can be best replaced, it is therefore necessary for us to study the different kinds of food ; to ascertain how much is required to keep a person alive and to enable him to do his daily work, and to know the different ingredients, and the proper proportions which are necessary to keep him in a satisfactory state of health. *A perfect food is one which contains in the proper proportions all the materials for the production of energy, the repair of waste, the building up of new tissues, and the production of heat.*

CLASSIFICATION OF FOOD STUFFS.

Food may be divided broadly into two classes—the **Organic** and the **Inorganic,** as is shown in the following table :—

Organic.

Nitrogenous (Flesh Formers)	Albumen as in Meat and Eggs. Fibrin .. Blood. Gelatine .. Bones Casein .. Milk. Gluten of Cereals.
Non-nitrogenous (Heat and Force Producers)	Hydrocarbons, as in Oils and Fats. Carbohydrates ,, Starch and Sugar.

Inorganic.

Salts	Chlorates of Potash and Soda. Phosphates of Calcium, Potash, etc. Iron, etc.
Gases	Oxygen, Nitrogen (as in the air).
Water.	

The **Inorganic** consist of *water* and the *minerals*, such as salts, potassium, iron, phosphorus, etc., all of which enter into the composition of our bodies. *Iron*, for example, is an important part of the red blood cells of which I have already told you. *Phosphorus*, in the form of phosphate, is required for the bones and brain, and we obtain it chiefly from bread and similar foods.

The **Organic** foods may be divided into two principal classes :—

1. Those containing nitrogen—Nitrogenous foods.
2. Those without nitrogen—Non-nitrogenous foods.

Nitrogen is a substance which is very plentiful in the world and exists naturally in the atmosphere in the form of a gas. In every 100 parts of air there are 79 parts of nitrogen. Although it is not required by us for breathing purposes, yet it is absolutely necessary that it should form part of our food, for without nitrogen life cannot be properly sustained.

Nitrogenous foods, or **proteids** are composed principally of Carbon, Nitrogen, Hydrogen and Oxygen with a little sulphur or phosphorus, substances which we have seen are found in the human body. Eggs, meat, peas, beans, etc., are examples of Nitrogenous foods. They are required for the construction of new tissue, such as the formation of muscle, so that people who do a great deal of muscular work do it better if they have a considerable amount of this particular kind of food.

If we take away nitrogenous foods altogether, death would eventually take place from want of nitrogen.

Non-nitrogenous foods are divided into two classes :—

1. The **Hydrocarbons.**
2. The **Carbohydrates.**

As both of these names show, these substances are composed of carbon, hydrogen, and a little oxygen.

Hydrocarbons or fats consist of carbon and hydrogen with very little oxygen, and are obtained from both the vegetable and animal kingdoms. From the animal kingdom, we get *beef* and *mutton fat*, *butter*, and *lard* ; from the vegetable, *palm oil*, which takes the place of butter and lard

for cooking in this country, *olive oil*, *ground-nut oil* and so on.

Fats or *oil* are necessary for the well-being of the body, because it is found that if an individual is deprived altogether of fats, even though plenty of other food is taken, the body is not so well nourished.

Then another important use of fats is that they are necessary for the production of force or energy, which enables us to work. These have been shown by very careful experiments. A third use of fats is the maintenance of the body heat. This is not so important in a hot country, but in the Arctic regions, the natives eat enormous quantities of fat in order to keep themselves warm. We see, then, that fats are very necessary, *because* (1) *they help digestion*, and thus the body is better nourished; (2) *they produce energy*; (3) *they maintain the body heat.*

On the other hand, if an excess of fat is taken, it tends to be stored up in the body, and makes the individual fat, and it also tends to produce disorders of digestion and of the liver.

The next class of foods is the **Carbohydrates.** These also contain Carbon, Hydrogen and Oxygen, but their proportions are different. There is twice as much Hydrogen as Oxygen, which is the same proportion as in water, hence the name Carbohydrate. They comprise the various starches, sugars, and gums, and are derived almost entirely from the vegetable kingdom.

Starch is the principal ingredient of many common articles of diet in this country—potatoes, rice, Indian corn, cassava, cocoa, arrowroot, and so on. When you look at starch under the microscope you will see it consists of small white grains, which differ in shape in many plants. Starch does not dissolve in cold water, but on adding boiling water, the little grains burst, and form a kind of paste. Cooked starch is digestible, but uncooked starch is very difficult to digest. Raw cassava, which you see labourers so often eating, is not only indigestible because it is swallowed in lumps, but because the starch is not cooked.

Sugars are also derived from the vegetable kingdom, principally from sugar-cane and beetroot.

The use of Carbohydrates is much the same as fats; they *produce fat*, and they *maintain the heat of the body.* They are, however, not so indispensable as the fats.

Now it must be remembered that these two groups are not in themselves sufficient to maintain life owing to the waste in the body. Nitrogenous substances are lost, hence we must always have nitrogenous substances in some form or other in our diet.

DIFFERENT KINDS OF FOOD.

Having thus considered the great division of foods and their special uses, I now go on briefly to consider the different kinds of food a little more. And first, as to nitrogenous animal foods.

I show you a table here giving the amount of carbon and nitrogen of different kinds of food.

NUTRITIVE VALUES OF FOOD.

In Grains per Ounce.

	Nitrogen.	Carbon.		Nitrogen.	Carbon.
Uncooked meat...	14·3 ...	35	Maize	7·0 ...	169
Cooked meat ...	19·3 ...	110	Arrowroot ...	0·6 ...	162
Fat pork	6·9 ...	189	Peas	15·4 ...	156
Dried bacon ...	6·2 ...	265	Potatoes	1·4 ...	45
White fish	12·6 ...	48	Butter	0·7 ...	299
Poultry	14·7 ...	57	Eggs	9·4 ...	68
Bread	5·5 ...	116	Cheese	21·0 ...	161
Wheat Flour ...	7·7 ...	166	Milk	2·8 ...	30
Barley Meal ...	8·9 ...	173	Cream	1·9 ...	100
Rice	3·5 ...	175	Sugar	— ...	178
Oatmeal	8·8 ...	168	Porter	0·06 ...	17

An Ounce = 437·5 Grains.

Meat may be divided into two classes—red meat and white meat. Of the *red meat*, beef, mutton, pork, and some kinds of fish, as salmon, are examples. As *white meat* we have all the fish we get in Sierra Leone, and the flesh of fowls and turkeys, turtle, lobsters, oysters, etc. White meats, as a rule, are more digestible than red meats. They contain, however, less nitrogen, and are therefore somewhat less nutritious. Oysters are very nutritious, and very digestible when raw, but cooking makes them hard, leathery, and indigestible.

Beef is the most common form of nitrogenous food, and is the most strengthening and nutritious of the animal foods, but is somewhat strong for delicate stomachs. Mutton is much more digestible. Pork, again, is extremely indigestible. Good beef should be firm, reddish in colour, and with a certain amount of fat in it. Here, very often during the dry season, the meat is very poor in fat because the cattle are not properly fed. It is also often of a deep purple colour, showing that too much blood has been left in it. Immediately after a bullock is killed it should be bled, and all the blood drained out of it. Then, too, meat should be properly cut up into joints, and not cut up in the indiscriminate way which is done here.

One of the best forms of nitrogen as food is **eggs.** An egg consists of two parts—the white and the yellow part, or yolk. The *white part* consists of what is known as albumen, and a good deal of water. It is very digestible when raw or lightly cooked, but, when very firm, it is indigestible. The *yolk* contains a great deal of fatty matter and phosphates. Eggs are extremely nutritious, and are one of the best and most digestible forms of food one can have. They contain everything essential for the support of life except starch or sugar. In this country eggs are very little used as an article of diet by the natives, and I suppose the result of this is that they are very small and difficult to get. This is due principally to want of care in breeding fowls and in feeding them. They are generally allowed to pick up any food they can get. There is no reason why large fowls and large eggs should not be got here as elsewhere, and it would probably pay to go in systematically for breeding them.

The shells of eggs are very porous, and consequently they get rotten very quickly in this warm climate. If we keep the air out by covering them over with salt butter, they will keep very much longer. Now we often get bad eggs in this town, and I will tell you how to tell a good egg from a bad one. Take an ounce of salt (a tablespoonful) and put it in a tumbler full of water and place the egg in it. If it is bad it will float in the mixture. It will even float in fresh water if it is very rotten.

EGGS.

	White.	Yolk.	Whole.
Nitrogenous (Albumen) ...	20·4	16·0	14·0
Fatty Matter	—	30·7	10·5
Salts	1·6	1·3	1·5
Water	78·0	52·0	74·0
	100·0	100·0	100·0

There is another article of food which is almost entirely neglected in this country, namely, **milk.** Now milk is a substance which contains everything that is necessary to support life. It contains nitrogenous substances, fats, a kind of sugar, and mineral substances and water. When a child is born all the food it lives on, or ought to live on, for six or seven months is milk, and it will thrive and grow fat on this, showing that it is getting everything that is required. Here, so little is milk used that the cows are not even milked, while in England milk carts go round two or three times a day distributing milk. In this country, though cows thrive very well, the only kind of milk we can usually get is in tins.

The sweetened condensed milk is nutritious because it contains a great deal of sugar, but the amount of milk is much less and is more indigestible. "Ideal" milk or other unsweetened milks are prepared by slowly evaporating a great deal of the water. It is a fairly good substitute for fresh milk, but is not so digestible. For children there can be no better form of food than plenty of milk, and I should be glad to see it used more extensively in this community. It is almost indispensable in cases of sickness, on account of its easy digestibility.

It is largely used in the Colonial Hospital, but it is strange how some of the patients dislike it, and think they are starved if they only get milk. In England, sometimes, cases of typhoid fever are fed on milk only for days together.

MILK.

	Cow.	Human.
Casein (Nitrogenous)	4·1	3·35
Fat (Cream)	3·9	3·34
Sugar of Milk	5·2	3·77
Salts	0·8	—
Water	86·0	89·54
	100·0	100·00

But in addition to these animal foods there are a number of vegetable foods which also contain nitrogen, and of these one of the most important is **wheat,** which is used for making bread, biscuits, maccaroni, and so on. **Flour** contains 7·7 per cent. of nitrogen and 166 of carbon. Wheat is first crushed and sifted, the central part giving the flour and the outer the bran. White bread contains flour only, while brown bread contains both bran and flour, and though, it is more nourishing, it is also more indigestible.

You will observe that in making bread the composition of the flour alters, it loses both nitrogen and carbon, but at the same time it gains in digestibility. Now the disadvantages of bread as diet are that though it has a good deal of nitrogen and carbon, it is poor in fats and salts, and this difficulty is got over by the practice of adding butter or fat to bread when we are eating it. Bread is more or less of a luxury here; wheat does not grow in this country, and all flour has to be imported. We cannot, therefore, look upon flour as one of the ordinary articles of diet in this place.

Flour, if simply mixed with water and baked, makes an indigestible cake. In order, therefore, to make bread light, yeast is added to it, or in this country, palm wine. Now yeast is one of those bodies which I talked about in my

first lecture on germs. This germ possesses the power of fermenting and breaking up the starch to form carbonic acid gas, and it is this gas which forms the holes you see in bread and which makes it light. Fresh bread is more indigestible than stale bread, and toasted bread is still more digestible because the toasting breaks up the starch grains.

Rice is a very good article of diet, but this ought to be classed among the non-nitrogenous foods, as it contains a small proportion of nitrogen and a great deal of starch, and is very poor in fatty matter, so that it is less valuable than bread for its nutritious qualities. It is, however, an extremely digestible form of starch, and, as I shall show you, by adding other things to it we can increase its nutritive value. Country rice is more nourishing than Indian rice, for the latter is cleaned much more. The country rice always has a certain amount of the bran remaining.

Indian corn or **maize** is another important article of diet in this place, being used to make **agidi** and **pap.** In other parts of the world it is ground up and made into cakes or porridge, and is then a valuable food, as it contains fat as well as nitrogen and carbon. Here, what is called Agidi is almost pure starch and is very like cornflour. It is prepared by allowing the corn to soak for some time till it gets sour, then it is pounded, strained, and the white sediment cooked to form Agidi. Probably the fermenting breaks up the starch grain and makes it more digestible.

Pap or Ogie is prepared from Indian corn also, and is really a kind of cornflour or arrowroot. It is suitable for sick people or children.

The **potato** does not grow here, but this is another starchy food which is used very largely in many parts of the world. Its place is taken here by the **yam** and **sweet potato.** It contains very little nitrogen and a considerable amount of carbon, about 1 to 40, so that to make it nutritious some other food containing nitrogen must be added. Yam is made in this country into *Foofoo*, the only objection to which is that it is very adhesive, and is apt to be swallowed in lumps which are indigestible. Yam is much more digestible when well boiled and grated.

Another starchy food which is commonly used here is **cassava.** This is prepared by soaking in water for some days by means of which a poisonous substance called *prussic acid* is got rid of. It is then grated and made into **foofoo.** Another way is by grating and then squeezing in a basket with stones, which also gets rid of the poisonous juice, and at the same time a certain amount of starch, and probably gluten, is got rid of, for I understand that if the washing does

not take place, that the foofoo is thick and sticky. But what is left is almost pure starch and vegetable matter.

There is another article of food which is also very nutritious, namely, **peas** and **beans,** and they are very valuable, because, as you will see from the table, they contain a large proportion of nitrogen—very nearly as much as some meats. In India cooked peas are eaten with rice to supply the proper amount of nitrogen. Here, beans are used under the form of "*Akara*," which, is made of beans pounded up, formed into cakes and fried with oil, so that you have not only nitrogen and carbon but fatty matters. It is the custom in this country to eat akara with ogi or pap in the morning, the former supplying the Nitrogen and fat, and the latter starch or carbohydrate, so that it is really a very scientific combination.

Then of *non-nitrogenons animal food* we have **butter** and **lard,** but they are not in universal use here, their places being taken by non-nitrogenous vegetable oils, such as **palm oil, ground-nut oil,** and **"doney"** or shea butter.

There is another very valuable article of food—namely, **sugar**, which is got from the sugar-cane or beetroot. In this country, sugar is not made, but I observe that a good deal of cane is grown, which people seem to be very fond of.

There are, in addition, a number of **vegetables,** such as *spinach*, *greens*, *sorrel*, *or sour-sour*, *krane-krane*, *okro*, *bitters*, *jackato*, *bologi*, *borbor*, and *tola*. They are used in making "palaver sauce," and in the ordinary stews. These vegetables are not, strictly speaking, foods, but they are very important in providing the mineral salts and vegetable acids of which I spoke to you. It is found that if people are deprived entirely of vegetables they get a disease called scurvy, and this was very common on ships in olden times.

Lastly, there are certain articles, such as salt, pepper, mustard, called **condiments.** Locally, *Kindah*, prepared from the locust bean, *red pepper*, and sometimes *Ogiri*, are the usual condiments. Though not actually foods, they are of value by making the food more palatable, and they also aid digestion by stimulating the stomach. Of course too highly seasoned things are to be avoided, as they exhaust the stomach, and end by causing indigestion.

A Mixed Diet necessary.

I have thus gone over very briefly the different kinds of food, and it will be evident to you that as these foods contain Carbon and Nitrogen in varying proportions and as the body requires daily its proper quantity of them, the *diet must be a*

mixed one. Let me try to make this clearer to you. We have learnt that the human body uses up daily about 4,500 grains of Carbon, and 300 of Nitrogen, and that that loss must be made up. Suppose a man were to eat meat alone, he would require about 3 lbs. to give the proper amount of Carbon, but he would then have a very large excess of Nitrogen.

On the other hand if he tried bread alone, he would have to eat over three pounds a day to get the necessary 300 grains of Nitrogen, while he would have far too much Carbon.

We must then combine the two, and it will be found that about 2 lbs. of bread and ¾-lb. of beef will supply just about the proper quantity of Carbon and Nitrogen.

And the same applies to rice and foofoo. If you live simply on them, you get far too much Carbon and too little nitrogen, and consequently fish, meat, peas, or beans, should be added to make up the necessary amount of Nitrogen. That is one reason why people here eat such large quantities of rice and foofoo. They do not add enough meat or fish to it, and the body craves for more Nitrogen to enable it to do its work properly, so that a large bulk of rice (containing little nitrogen) has to be eaten. Hence we get distended stomachs and indigestion.

Another disadvantage of eating one food only is that it palls upon us, the appetite fails, and we have to have recourse to condiments, peppers, etc., which again disturb the stomach.

What then is the proper diet, and how much does a man require to keep himself in health? The following table gives you an idea of this, and you will observe that a healthy man requires 4·3 oz. of nitrogenous matter (that is, meat or fish), 3 of fat, 11 of starch (bread or rice), and about one ounce of salt, equal to 20 ounces of dry food, or about a pound and a quarter. To this must be added three or four pints of water.

Daily diet of healthy adult.

Dry Food.		Moleschott.	Parkes.	
			Labour.	Rest.
Proteid ...	...	4·32 oz.	6 to 7 oz.	2·5 oz.
Fat ...	...	3·174 ,,	3·5 to 4·5 ,,	1·0 ,,
Carbohydrates	...	11·64 ,,	16·0 to 18·0 ,,	12·0 ,,
Salts ...	... nearly	1·00 ,,	1·2 to 1·5 ,,	0·5 ,,
		20·134 oz.	26·7 to 31·0 oz.	16·0 oz.

The second part of the table shows that when a man is at rest he requires less food, 16 ounces, and if working hard 1½ to 2 pounds a day.

Now I need not go into the method of calculating the proper quantities of food and their ingredients, for it is rather intricate, but the following may be taken as constituting a **fundamental English diet** :—

Foundation—	1 lb. Bread.
	½ lb. Meat.
	¼ lb. Fat.
Accessories—	1 lb. Potatoes.
	½ pt. Milk.
	¼ lb. Eggs.
	⅛ lb. Cheese.

Now, here, this diet is not applicable, less meat is required owing to the tropical climate, so what would constitute an ordinary diet? Most of the people are really vegetable feeders, that is to say the principal part of their food is rice, cassava, yam, or some vegetable of that kind. These contain too much carbon by themselves, so that something must be added to give the necessary nitrogen. This is done by means of meat, fish, or the beans which you use in the form of Akara, and the necessary fat is given by palm or ground-nut oil. Dry rice or foofoo and a little bit of fish, are not enough for hard work if it is continued for any length of time; and that is probably why it requires more labourers here to do a certain amount of work than it would English labourers, who have a much more nitrogenous diet.

The following diet may be taken as a suitable one for a native doing a fair amount of physical work :—

12 oz. rice and 1 lb. foofoo.
3 oz. beef or 8 oz. fish.
½ oz. salt.
5 oz. (about) greens.
1 oz. to 2 oz. palm oil, and the necessary condiments.

To this diet 2 oz. of split peas or beans should be added three times a week. There is rather too much carbon and too little nitrogen, but it is a fair working diet for this country. Of course it can be altered to suit taste. If you like eggs, you can diminish the beef; or if you eat bread, less rice and less foofoo are necessary.

DISEASES CAUSED BY FOOD.

And now a few words as to the **diseases** which are connected with food. Some of them are already known to you —Trichina from pork, tape worm from beef, consumption from

eating meat or drinking milk from a tuberculous cow, and so on.

Excess of Food or over-eating tends to produce disorders of the stomach. There is too much for the stomach to digest properly, and the food begins to ferment and undergo putrefaction in the intestinal canal, and these products of putrefaction are absorbed and the person feels heavy and languid, sometimes gets jaundice, and occasionally diarrhœa. A great many of the common complaints which are often called "biliousness" are simply due to over-eating. The old saying that one should always rise from the table feeling that you could eat more, is a very sound rule to follow.

Then **too little food,** which is known as starvation, has other effects. Fortunately it is almost unknown here, for life is so easy that food can always be obtained, and people are very good to one another, and appear to be very willing to give a little food to another who is not so well off. Indeed, it is a marvel to me how long some men manage to live out here without working—it could not be done in England. Too little food gradually produces wasting, loss of power, and if continued, will eventually end in death; and if nitrogenous food is taken completely away, it also causes loss of power and wasting. For example, man cannot live solely on sugar, for he will get ill if he does, and the same applies to fat. Similarly, if there is too much of these articles his stomach will be upset, so this shows again the necessity of mixing our food. I mentioned *scurvy* as a disease which is produced by eating too much meat and no vegetables. That is a disease which is rarely seen here.

TIME OF TAKING FOOD.

Then the **time of taking food** is important. It should be regular and the intervals not too long. I think the best arrangement in this climate is something light on getting up —tea or cocoa, and an egg, and perhaps some fruit, which is very beneficial in the morning; breakfast about 10 to 12 a.m., a fairly substantial meal; and dinner from 5 to 7. The later it is the lighter it should be, for it is not a good thing to go to bed with a loaded stomach. There is a considerable amount of irregularity among the natives here as to meals; they are apt to eat when they feel hungry and at odd times. You must remember that the stomach, after it has digested food, wants a rest before it is ready for the next, and that it likes to get its food regularly. If you keep rushing food into it between the regular meal hours it may stand it for some time, but eventu-

ally it will begin to object. There is no necessity either for eating or drinking between meal hours.

All food should be well chewed before it is swallowed, and meals should be taken slowly. Large quanties of fluid should not be taken with a meal, as it dilutes the gastric juice, and prevents its action. It is a good thing to sit down and rest for a short time after a meal, before resuming work.

COOKING.

There are several reasons why food should be cooked :—

1. It renders it more pleasant to the eye, and to the palate. Cooked beef for example is more attractive than raw meat.

2. It is rendered more digestible. Meat in its natural state is tough and stringy, but the process of cooking softens the fibres, coagulates the albumen, and makes it more readily broken down by the teeth, so that it reaches the stomach in a more digestible form. It also breaks up the starch granules, which are otherwise very indigestible.

3. The warmth of cooked food assists digestion, and has a stimulating effect. Hot soup for example is much more stimulating than when cold.

4. Cooking kills any germs of disease and parasites which may be present.

5. It prevents putrefaction, and should it have begun slightly to decay, it minimises the bad effects.

METHODS OF COOKING.

There are many different methods of cooking, the principal of which are, boiling, roasting, grilling, stewing, baking, and frying.

Boiling is used for two purposes—for making soup and with a view of eating the meat, and it is important to remember that in each of these cases it should be done differently. *To make soup*, the meat or fowl should be cut up into small pieces and placed in cold water, left for some time, and then slowly heated to extract all the food out of the meat, which is left with little nourishing matter in it and is tough and indigestible. Beef tea for sick people, for instance, should be made in this way with very little water. When the fowl or *meat is to be eaten*, on the other hand, it should be plunged into boiling water, by which means the outside is hardened and all the juice kept in.

In **stewing**, which is such a general form of cooking meat out here, a certain amount of water is added, and then

the meat is cooked slowly, so that part of the juice comes out and forms the sauce and part remains in the meat. Then various condiments can be added to flavour the dish.

Roasting is less digestible than either boiled or stewed but has perhaps rather more flavour than the former.

Frying is the most indigestible way of cooking, as the food gets penetrated to some extent with fat, and especially here, where cooks have a very bad habit of frying things a little bit, and then letting them get cold and warming them again.

Cooking, then has very considerable importance in connection with digestion and nutrition, and more attention should be given to it in this country than is the case.

BEVERAGES.

Before leaving the subject of food, I have a few words to say to you on the subject of **Beverages.** These may be divided into two classes, Non-intoxicating, and Intoxicating.

The most important **Non-intoxicating** drinks are Tea, Coffee, and Cocoa.

Tea consists of the dried leaves of a shrub which grows chiefly in China, India, and Ceylon. They are green at first, but turn black according to the method of preparation. A beverage is prepared from the leaves by pouring boiling water over them, and it is essential that it should be properly made. First of all the tea-pot should be heated by partly filling it with hot water and emptying it. Then the dry tea leaves are put in, and water, which is actually *boiling*, should be poured over them. It makes better tea if the water is not allowed to boil for any length of time. Then it should be allowed to stand or " infuse " for a few minutes, when it may be used, or poured off into another hot tea-pot. If it is allowed to infuse for more than five minutes, a large quantity of *tannin* is extracted from it which is injurious to the walls of the stomach. Tannin is the substance used for making skins into leather, so you can understand how bad it must be for the stomach.

The action of tea depends upon the presence of an active principle called *Thein.* Tea is in no sense a food, but when properly made is of very considerable value as a stimulant to the nervous system, and it has this very great advantage over alcohol, that it produces no subsequent depression. If, however, it is taken to excess, or is badly prepared, it produces nervousness, palpitation, loss of appetite and indigestion. The use of milk and sugar add a certain amount of nourishment to its stimulating qualities.

Coffee is the seed or berry of a plant growing in many parts of the tropics, chiefly in Arabia, the West Indies, and West Africa. It grows readily here, and Sierra Leone coffee is one of the best. It is prepared by roasting the seeds to a chocolate brown, grinding them, and then infusing with boiling water. Many people make the mistake of using too little coffee when preparing it. An ounce or a large table-spoonful should be used for each cup. It has an active principle called **Caffeine,** and its action resembles that of tea, being stimulating without any after depression, and lessening the sense of fatigue. It contains less tannin than tea, and like it, is not a food.

Cocoa is the seed of a plant growing chiefly in the West Indies, but latterly it has been successfully grown in West Africa. The seeds are taken from the pod, allowed to ferment, then roasted and ground. It contains a stimulating substance called **Theobromine,** similar to Thein and Caffeine, but in less quantity. It is, therefore, less stimulating, but as, in addition, it contains starch, fatty matter and nitrogenous substances, it has the advantage of having very marked nutritive properties, and is consequently a very valuable food.

Kola, which grows very plentifully in this country is allied to these, and contains a similar stimulating principle. At the same time, there is a very large quantity of tannin, which prevents its being made into an agreeable beverage. When chewed, it has undoubtedly a very stimulating effect, and enables people to undertake a very much greater amount of physical work, then they would otherwise be able to do.

Of Aerated waters little need be said. They are simply flavoured waters, charged with Carbonic Acid Gas, and are pleasant drinks without any dietetic value.

The **Intoxicating** Beverages include all the forms of alcoholic drinks.

You have already learned that alcohol is produced by fermentation caused by a germ—the yeast plant—which has the power of breaking up sugar into alcohol, carbonic acid gas and other products; and the fermentation of palm wine was mentioned as an example of this. New palm wine is non-intoxicating; old palm wine is very intoxicating, and the process which takes place naturally in palm wine is practically the same as is carried out artificially in the manufacture of all beers, wines and spirits. In some cases, the alcohol is produced directly from grape sugar as in wine made from grapes, while in others starch is the basis, as in malt. The starch is first changed into sugar, which in its turn breaks up into alcohol.

The various **wines,** claret, port, sherry, champagne, &c., are prepared by fermenting the juice of the grape.

Beer and **ale** are prepared from barley, which is first soaked and then spread out for some days, during which time the grain ferments and the starch is transformed into grape sugar. Yeast is then added to it, changing the sugar into alcohol. It is then flavoured with hops, from which the bitter taste is acquired. **Porter** and **stout** are prepared in much the same way, the dark colour and peculiar flavour being due to burnt malt. Ales and stout contain a slight amount of nutriment owing to the presence of sugar.

Brandy is prepared by distilling the juice of grapes, though the cheap brandies are made from potato spirit.

Whisky is made from malted grain; **Gin** in the same way but flavoured with oil of Juniper and other substances, while **Rum** is obtained from the juice of the sugar cane.

Brandy, whisky, gin, and rum are known as spirits, and contain a very large proportion of alcohol. They contain no nourishment, and are simply stimulants.

Action of alcohol.

The first effect of alcohol is *stimulating*. When it is swallowed, it passes directly through the lining membrane of the stomach into the blood, the heart beats more rapidly, the breathing becomes quicker, and all the small blood vessels of the body become dilated. Owing to the dilatation of the small vessels on the surface of the body, a loss of heat takes place and the temperature of the body is lowered. There is a common idea that alcohol will warm you on a cold night, which is a most dangerous mistake. It gives a temporary feeling of warmth, owing to the skin becoming full of blood, but the general temperature of the body falls. Then follows a period of *depression*. If more alcohol is taken, the muscles and nerves become affected, the person loses control over his limbs, he cannot walk or talk properly, the senses become dulled, and finally his brain is affected and he falls into an unconscious state from which he can be roused with difficulty, and if the amount of alcohol has been excessive, this condition may end in death.

If alcohol is taken habitually in considerable quantities the effects become permanent, and the individual's constitution undergoes a profound change. The permanent dilatation of the superficial blood vessels is seen in the flushed and bloated face of the habitual tippler, the mucous membrane of the stomach is destroyed and digestion suffers, the liver becomes hard, the kidneys alter and do not excrete properly, the brain

and intellect are dulled, and the individual becomes a mental, moral, and physical wreck, a curse to himself and to those in contact with him.

Alcohol cannot be regarded as a food under the ordinary conditions of life. The amount of pure alcohol which can be disposed of in the body in health in twenty-four hours is only about $1\frac{1}{2}$ ounces, which is equal to about a pint and a half of light beer, and about three ounces of brandy or whisky, or a small wineglassful. Anything beyond this is harmful, and even this is not a necessity. It has been clearly shown that hard work can be done, and better done, without alcohol than with it. In some conditions of over fatigue and in the old and feeble it is, however, of some value, and sometimes alcohol, just before or with a meal, will stimulate the appetite and allow food to be eaten which would otherwise not be partaken of. It should never be taken between meals or during working hours, but a little after the day's work is done, may be beneficial.

In disease, under medical direction, it is often of the greatest service.

We may then, come to the following conclusions :—

1. Alcohol is **not a food,** and is **not a necessity.**
2. It should **never be taken between meals.**
3. It should **not be taken during working hours.**
4. It should **not be given to children.**

LESSON XI.

WATER.

A good supply of pure, wholesome **water** is another of the important necessities of life, and is even more essential than food, as we can exist longer without one than without the other. If we could imagine ourselves totally deprived of water for two or three days we could get some idea of how necessary it is to us, and some of the people in this town know in part the very great inconvenience which has arisen from the supply of water running short towards the end of the dry season. But we are very fortunate in Freetown, for not only have we a large rainfall, but we have the hills behind us to collect it, and streams to bring it down, and now we may congratulate ourselves on having a supply of water which is not only pure and wholesome, but is plentiful, and compares very favourably with many English and Continental towns. On many parts of the west coast—for example, at Lagos and at the Gambia—the whole of the water is derived from rain water stored in tanks or from shallow wells, which, as I shall show you, are liable to be contaminated in many ways.

We have learned that water forms the great bulk of the human body ; that it forms an *essential part of our food*, softening it and aiding absorption ; and that is assists in the removal of waste matters. But it is also required for other purposes, *cooking*, *cleansing*, *washing*, *bathing*, and other domestic purposes, for *watering the streets*, for *manufactures* and so on. The **amount of water** required per head of the population may be put down as a **minimum of fifteen gallons**, but for a good service thirty to **thirty-five** gallons are required. In this place, much less than the latter quantity is necessary, because there are no large manufactures, and no water system of sewage removal.

The following table may be taken as a standard :—

WATER CONSUMPTION (PARKES).

	Gallons.
Cooking	·70
Drinking	·30
Ablution	5·00
Domestic—	
House Cleaning	3·00
Laundry	3·00
Baths	4·00
W.C.	6·00
Waste	3·00
Municipal	5·00
Manufactures	5·00
Per Head of Population ...	35·00

COMPOSITION OF WATER.

Now, what is **water?** You are getting quite learned now in gases and chemicals, and know that the principal parts of food are composed of Carbon, Nitrogen, and Oxygen. Well, water is composed of two of the chemical elements of which I have already spoken—namely, **Hydrogen** and **Oxygen**. These two bodies are gases, but if we take them in their proper proportions (two of Hydrogen and one of Oxygen) and put them together, we find that water will be formed.

Water exists under several forms. You all know it as the bright, clear, sparkling, tasteless fluid which you drink daily, and you are aware that if you boil it it forms **steam**. This is **watery vapour**, and it is diffused everywhere around us in the air. At this time of the year the air is full of watery vapour, which causes the damp feeling which we are all familiar with. Then, if it gets cold, much colder than we ever have it here, water becomes solid, and forms **ice**, which most of you have seen, as it is carried on the steamers, and made at the Ice Company. Watery vapour, when carried up in the air and meeting the cold, turns to water again, and comes down as **rain**, or in winter in England may come down as feathers of white **snow**, or little hard lumps of **hail**. Water is always going round and round in this way, and I show you here a diagram which illustrates this (Fig. 53). First of all, the great source of water is the sea, and from it a large amount of watery vapour rises, caused by the sun's rays. Some of this condenses, and forms **fog** and **mists**, which you know here as "smokes." Another part is carried into the air, and this forms the **clouds** which we see floating about in the sky, and which are really composed of masses of small

particles of water. This, in its turn, comes down in the form of **rain**, **hail**, **snow,** or **dew,** soaks into the ground, forms **springs** and **rivers**, and gets carried again into the sea.

Water may be divided into *hard* and *soft*, and is so described according as it can produce a good lather with soap

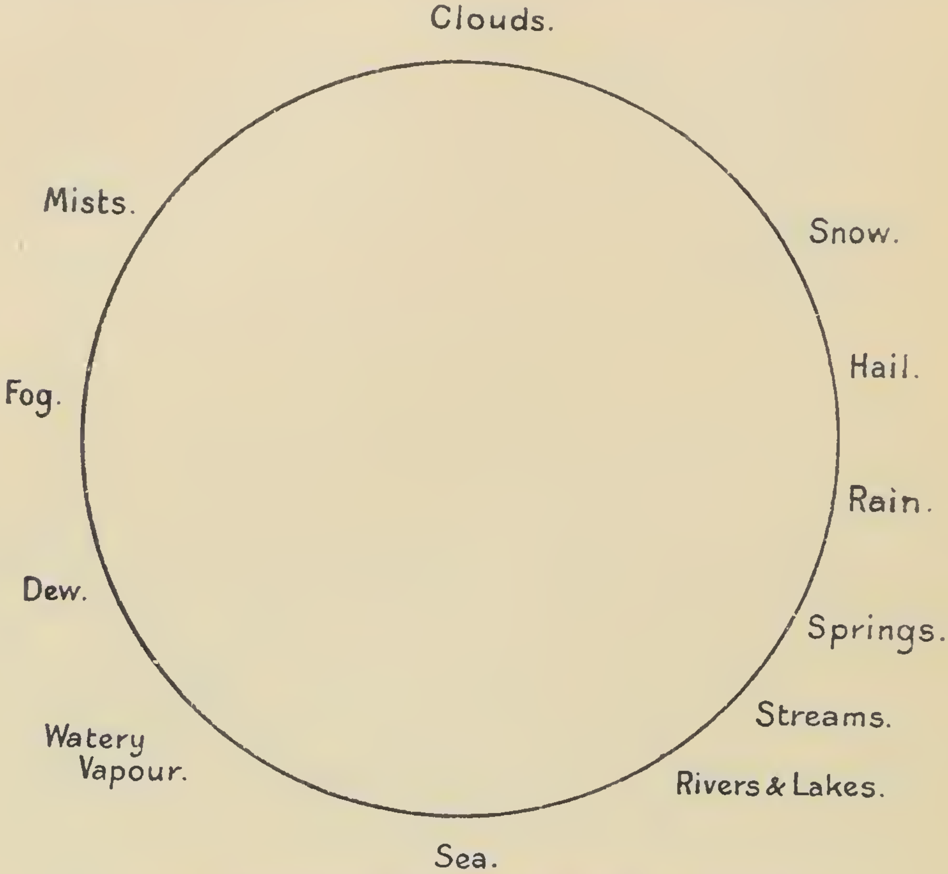


FIG. 53.—Diagram showing circulation of water.

or not. Hard water contains a lot of mineral salts in solution. Soft water is purer. Rain water is soft, and the water of this place is also soft, and is good for washing purposes. Soft water is also better for cooking purposes than hard, and is much better for making tea.

CHARACTERS OF A GOOD WATER.

A good water should fulfil the following conditions :—

(*a.*) It must be **colourless.**
(*b.*) It must be quite **free from smell.**
(*c.*) It must be **clear**, and free from sediment.
(*d.*) It must be **palatable**.
(*e.*) It should be **bright** and **sparkling**, that is, have a certain amount of air dissolved in it.
(*f.*) It should be **soft**.

The new water supply in Freetown answers to all these requirements.

SOURCES OF WATER.

The sources from which water is derived are various.

First of all, **rain water** may be stored in cisterns. It is a very pure source of supply, and all it contains are materials which it gets from the air. In this country it contains very little, but in large manufacturing towns it gathers a good deal of impurity.

The next source is **springs,** and you know of several in this town—Bobocombo and King Jimmy, for example. The rain falls on the ground, soaks into it until it finds some rock or clay through which it cannot pass, and then it runs along this until it finds an opening, where it bursts out as a spring. Another way is that it sometimes collects inside a hill and forms a big pool, finding its way out by a crack, and not coming to the surface for long distances sometimes. I show you here a picture (Fig. 54) which illustrates how springs are

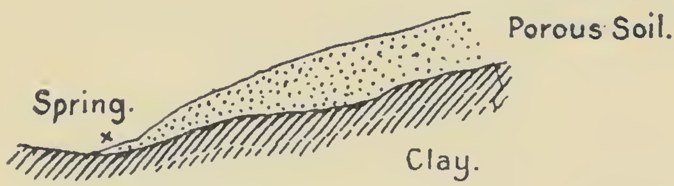


Fig. 54.—**Spring.**

formed; and I must tell you that everywhere under the surface, at varying depths, there is a layer of water which is known as the *subsoil water*, which forms pools under the ground, and which is always moving. In the rainy season it comes near the surface of the ground, and in the dry sinks lower.

Freetown slopes to the sea, for the most part, and if you go down to the Government Wharf and look at the cliff where the railway runs you will see this subsoil water oozing out Fig. 55 shows you a spring which is dry in summer and full in winter, as some of the springs here are, and this is due to the rise and fall of the subsoil water.

Spring water, as a rule, is pure, bright, and sparkling, and a good drinking water. In a town like this, however, there is very great danger of contamination, and all the

springs must be looked upon as dangerous. You will see in a moment how easily they may become polluted.

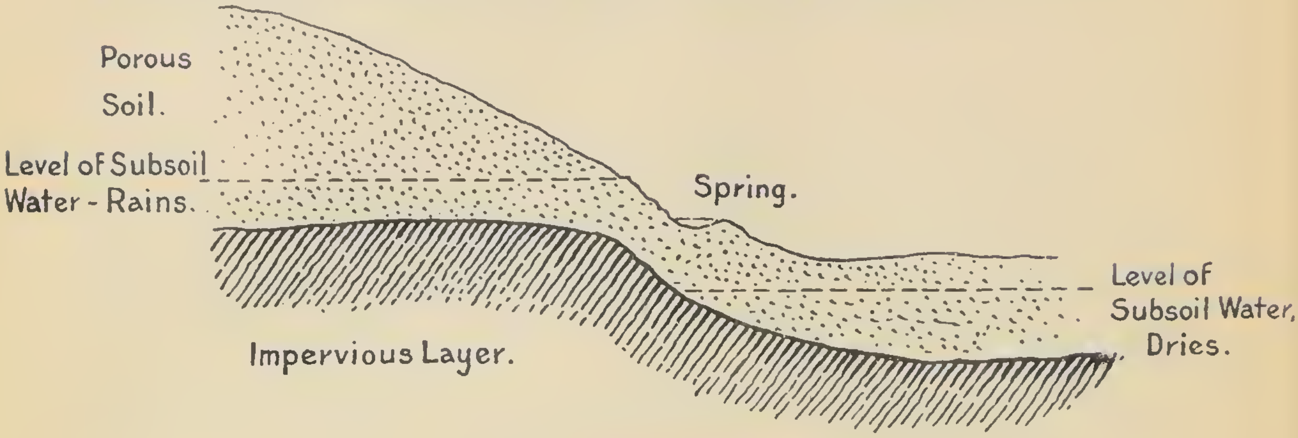


Fig. 55.—Intermittent Spring.

The next source of water is **surface wells**, which are so common in this town, and are practically the only means of getting drinking water in many parts of the town. I show you here a surface well (Fig. 56), from which you will see that it is simply dug until it reaches the subsoil water. In the country, and if the well is dug very deep, this source of water supply may be satisfactory, but in a town like this it is one of the most dangerous which can possibly be had recourse to, and if you look at the picture (Fig. 56) you will see how

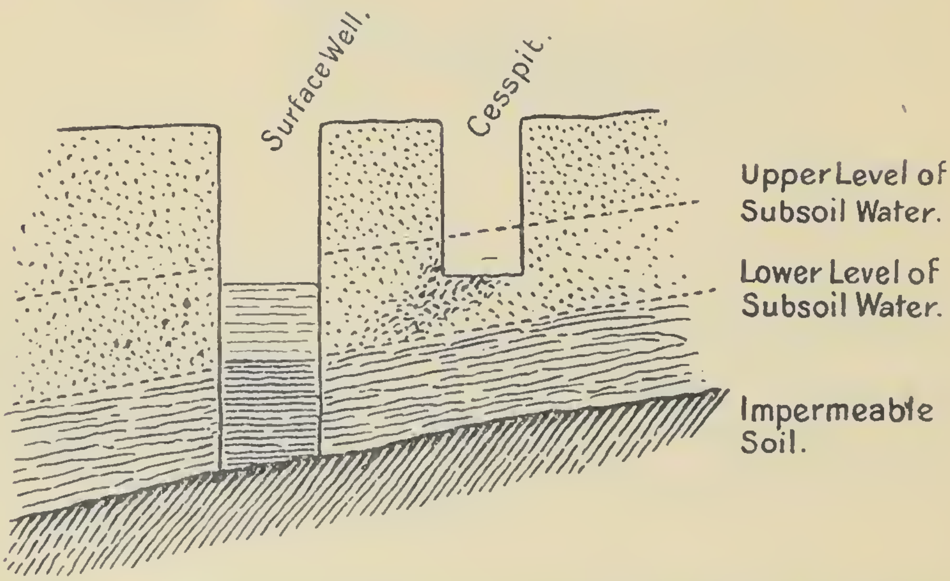


Fig. 56.—Diagram showing contamination of surface well by cesspit.

it is so. Here is a cesspit, and here the subsoil water, flowing as you see, in the direction of the well. The contents of the cesspit soak into the ground, and the matter from it reaches the subsoil water, and gets carried along, and eventually finds its way into the well, from which it is pumped up, and is drunk by the neighbouring people, so that if any disease gets into the cesspit, such as cholera, it can easily be carried into the well.

Similarly a river may become contaminated from the subsoil water (Fig. 57). In this place, where the whole place

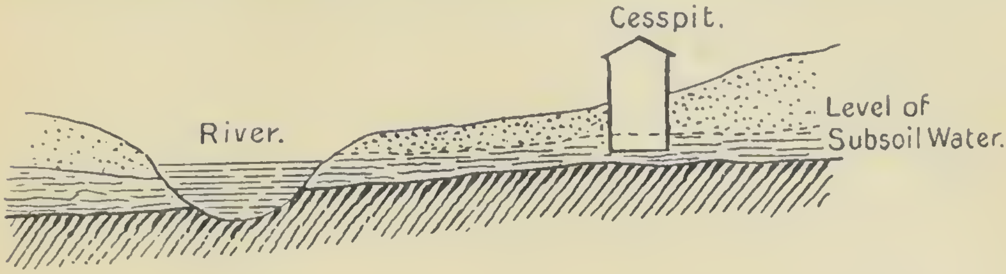


Fig. 57.—**Diagram showing contamination of river by subsoil water.**

is full or cesspits, and where we have a constant flow of subsoil water to the sea, I do not require to tell you how dangerous the wells are, sunk as they are, to a depth of from fifteen to thirty feet.

In one part of the town, I found a well, with no less than three cesspits above it, and the water in the well was of the most impure and poisonous description.

What wonder, then, that people have been dying from diarrhœa and other bowel complaints when they have been drinking such poison as this? *Every surface well in this city should be closed;* and now that we have a good water supply I shall urge, with all the force in my power, on the Government and on the Municipality, the necessity of closing up these wells in the interests of the people themselves. And not only can these wells get contaminated with the soakage of sewage from cesspits, but they have soakage from the surface of yards, while rain water is apt to wash dirt, eggs of insects, etc., into them. When I add that wells near the surface breed mosquitoes, I give you an additional reason why they should be closed.

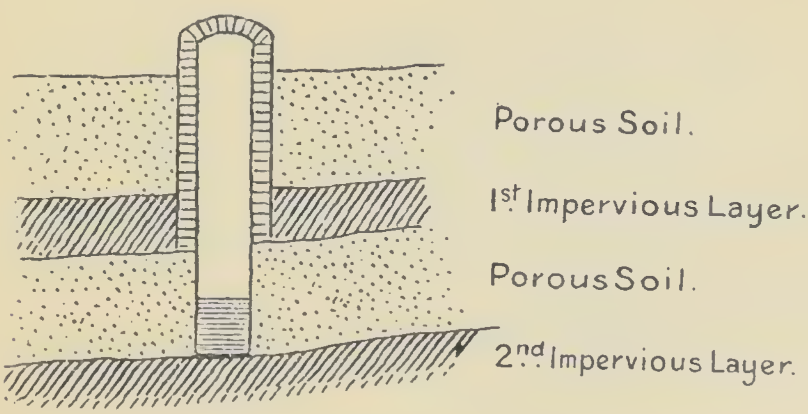


Fig. 58 —**Deep well.**

Deep Wells afford a safe and pure supply of water if they are properly constructed. They must be carried

through the subsoil water and the impervious layer beneath it until they reach a second impervious layer (Fig. 58). They must be thoroughly bricked and cemented down and into the first impervious layer and should be protected at the top by a low circular wall and cover.

A fourth source of water supply is, **river or stream water**. This, of course, will vary very much, according to the place from which the water is taken. For example, none of you would like to drink the water from Sanders' Brook down close to the sea after it has passed through the town, and people have washed and bathed in it, but up in the hills it is pure and wholesome, and it is from the hills that our present water supply is derived. A dam is built to collect the water, and this is carried to a large tank in town, where it is stored, and from which it is distributed over the town. We have had to be particularly careful about what is called the "collecting area"—that is, the ground where the water collects and runs into the dam—and nobody can build there, and there are very strict rules about washing or otherwise polluting the water. You have already been given an illustration (Fig. 57) of the contamination of rivers by sewage.

Another source is **Upland Surface Water**, that is water collected from moors or hills. It is as a rule a very good source of water supply.

In some places **Lakes** are used as a source of water supply, for example, Loch Katrine in Scotland which supplies Glasgow. The water is generally very pure, soft, and free from organic impurities.

The sources of water supply may be classified according to general fitness for drinking as follows :—

Good	1. Spring water.
	2. Deep well water.
	3. Upland surface water.
	4. Stream water from hills (uncontaminated.)
Suspicious	5. Stored rain water.
	6. Surface water from cultivated lands.
Dangerous	7. River water to which there has been sewage access.
	8. Shallow well water.

IMPURITIES IN WATER.

These may be divided into (*a*) **mineral** and (*b*) **organic** impurities.

Mineral impurities consist of substances derived from the soil through which the water passes. **Lime** for example may be obtained from the rocks, and chloride of sodium or **common salt** may be present if the water supply is near the sea. In this place, the water is very pure and contains little mineral matter.

Organic impurities may be either of animal or vegetable origin. Rain is apt to carry a certain amount of **vegetable matter** into the reservoir, but as a rule this is not dangerous. Here where vegetation is so luxuriant, it is almost impossible to prevent some vegetable matter from getting into the water, and it occasionally causes diarrhœa.

But the most important organic impurity is **sewage**, and I have shown you how readily the water supply from wells may become contaminated from cesspits. In this way, the germs of cholera, typhoid, dysentery, and diarrhœa may get into drinking water, and so into the body.

Other accidental contaminations are the **eggs of parasites,** tape worm, guinea worm, round worm and ankylostoma, which may be carried into the water supply by rain, or blown in by the wind.

PURIFICATION OF WATER.

This brings us to the **purification of water.** I have already told you of one method by which water can be rendered pure, and that is by **boiling,** and you have learned that it kills the germs, and also destroys the eggs of parasites. But boiling is apt to render water rather tasteless and flat, because it drives all the air out of it, and it is very difficult indeed to get people to carry it out, so that another method is generally used—namely, **filtration.** Now a great many people think that if they have a filter on their sideboards they are quite safe, and they do not think it matters what kind of a filter it is, or how it is kept. We know now that the diseases I have talked about are produced by germs, so that it is evident that the essential property of a good filter must be its power of *stopping germs.* The majority of filters do not do this. Carbon filters, for example, those pretty little blocks that you see so often in use, are not only useless, but often dangerous. They may stop germs for a few days, but very soon their power of killing germs gets exhausted, and they actually allow them to grow in them, and make the water more impure. The two best filters are what are called the Pasteur filter and the Berkefeld. These consist of small cylinders of porcelain, and the filter is so fine that no germs or suspended

matter can pass through. Fig. 59 shows a Pasteur filter for fitting on to a water tap, but portable kinds can be obtained. Another advantage of these is that they can be cleaned from time to time by boiling, and it is as well to brush them occasionally.

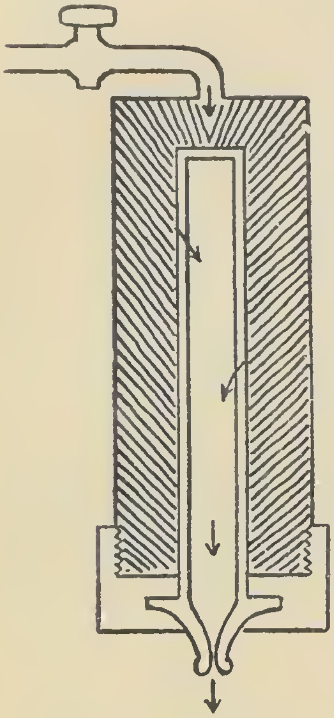


Fig. 59.— Pasteur Chamberland filter.

I have already told you that care should be taken to keep all vessels used for containing water scrupulously clean, and in this place it is absolutely necessary that all vessels in which water is stored should be provided with a proper cover, so as to prevent mosquitoes getting in. With the supply of water which we now have it should not be necessary to store more water than is sufficient for one day's use. If you do this you may be sure that no mosquitoes will breed in it.

There is another thing that I wish to mention to you, and that is about the standpipes. I have observed once or twice that people wash their feet and even their bodies at some of the standpipes, and very often put their mouths to the pipe to take a drink. These are very filthy habits, and calculated to spread disease, and I hope that if you see any one doing this you will do your best to put a stop to it.

LESSON XII.

AIR—RESPIRATION.

Air is another necessity of life, and so important is it, that if we are deprived of air even for a few minutes death takes place.

The act by which air is taken into the human body is known as **Breathing** or **Respiration**, and is effected by means of

THE RESPIRATORY SYSTEM.

This consists of (*a*) the **mouth** or **nose**, (*b*) the **pharynx**, (*c*) the **trachea** or windpipe, and (*d*) the **Bronchi** and lungs.

The Nose.

is really the proper organ for breathing just as the mouth is for eating. Owing to the arrangement of the bones inside it, it acts as a filter, and in cold countries serves the purpose of

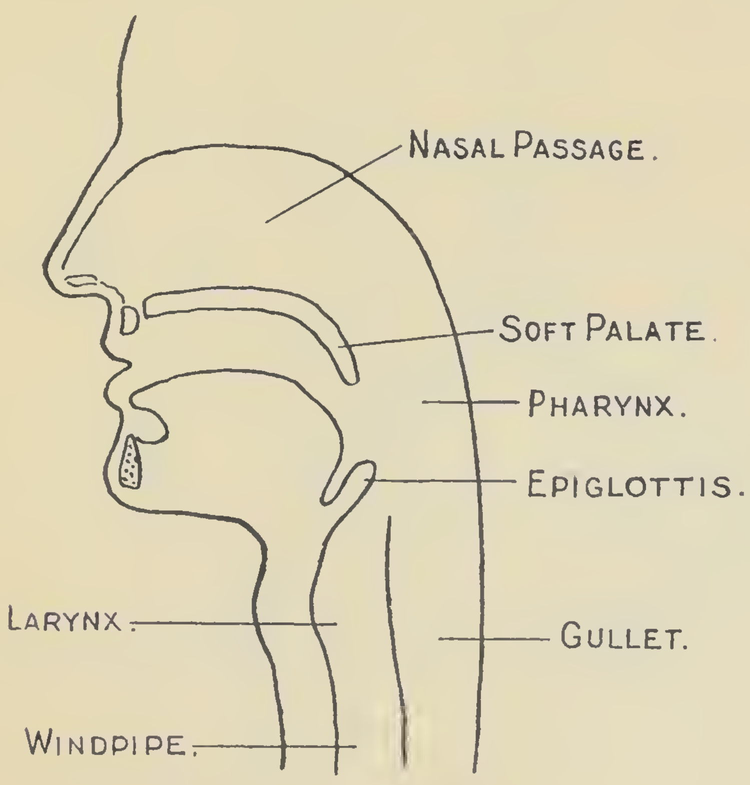


FIG. 60.—**Diagram of Face and Neck.**

warming the air before it is taken into the lungs. Behind, it opens into the

Pharynx.

This is really the back part of the mouth, and from the lower part, the gullet and the windpipe open, the latter lying just at the back of the tongue. (Fig. 60.)

The Trachea or Windpipe.

This is a large round open tube, about $4\frac{1}{2}$ inches long, lying right in front of the gullet.

At the upper part is a little lid which closes when food passes into the gullet, and thus prevents food entering the lungs. A little below is the **Larynx**, the organ by which we speak, and if you put your hand on your throat you will be able to feel it. The lump in the throat which is generally known as "Adam's Apple" is the larynx.

The Trachea differs from the gullet in the fact that it is always open, which is due to a large number of little rings of gristle or cartilage surrounding it.

The Bronchi and Lungs.

The trachea divides into two round tubes, called **Bronchi**, one going to the right side, and the other to the left, and

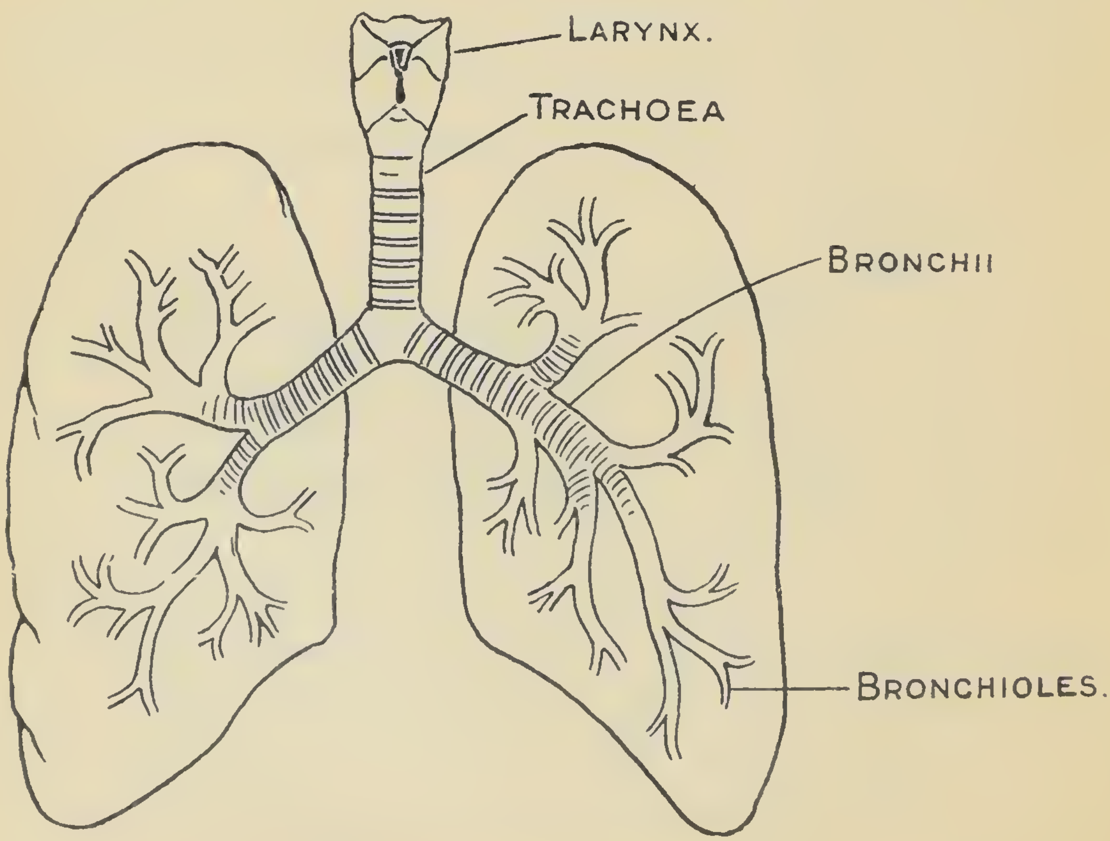


FIG. 61.—Bronchi and Lungs.

these divide again and again, until they form very small tubes called Bronchioles in the substance of the lung. (Fig. 61.)

They widen out at the end into spaces like little bags (Fig. 62), which are called **air cells**. These form the mass of the lungs and are connected together.

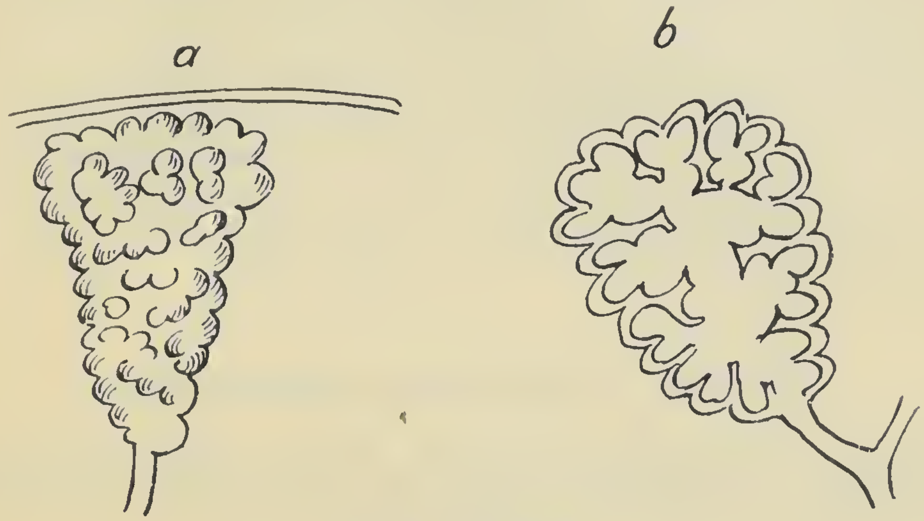


Fig. 62.—**Air Cells.**
(a) Outside view (b) in section

with fine connective tissue. Each air bag is lined with very thin flat cells, outside of which lie fine blood capillaries, so that the blood is separated from the air by a very thin partition only. The blood enters the lung along with the bronchi by means of the Pulmonary Artery, which subdivides until it reaches the fine capillaries, and leaves the lung at the same place by the Pulmonary Vein.

We see then that the lungs consist chiefly of air cells, with blood vessels surrounding them.

Externally, the lungs are covered by a thin shining membrane, the **Pleura**, which lies closely in contact with the chest wall.

RESPIRATION.

The act of breathing or respiration consists of two parts, **Inspiration** or the drawing of air into the lungs, and **Expiration** or the forcing of air out of the lungs. You will remember that the lungs are enclosed in a bony cage with movable walls, called the chest, and are separated from the abdomen by a muscular partition, the diaphragm.

During **Inspiration**, the capacity of the chest is increased in two ways, first by the diaphragm descending and becoming flatter, and second by the ribs rising, this being caused by the contraction of muscles lying between the ribs. Owing to the increase in size, air rushes into the lungs. In men we find that breathing is effected mainly by the diaphragm, *abdominal*

breathing, while in women, the ribs and breast bone are most important, *thoracic* breathing.

Expiration is effected by the weight of the ribs, and the elasticity of the ribs themselves, assisted in forced respiration by the action of the abdominal and chest muscles.

The average **rate** of breathing is 17 to 20 times a minute, and at each inspiration about 30 cubic inches of air are taken in, the same amount being forced out during expiration. This is what is called the **tidal** air. If we force our breathing we can expire another 100 inches of air, the **supplemental** air, and even then there is always left a certain quantity of air in the lungs, the **residual** air. The lungs then are never completely emptied.

Changes in air during Respiration.

Air is composed principally of three gases, **Oxygen, Nitrogen,** and **Carbonic acid,** in the proportions shown in the following table :—

Oxygen	20·81
Nitrogen	79·15
Carbonic Acid	·04
	100·00

Of these the important one for us is oxygen. The nitrogen is simply to dilute the oxygen, which, if pure, is too strong to breathe, while in pure air only a trace of carbonic acid exists.

Now what happens when the pure air is taken into and expelled from the lungs? First of all we have

Changes in the blood.

In describing to you the circulation of the blood, I told you that the impure blood from the body entered the right side of the heart and passed through the Pulmonary Artery into the lungs. (Fig. 9). It was then of a purple colour, due to the red blood cells being charged with carbonic acid gas which they have taken up in the body. The blood passes into the thin walled capillaries lining the air cells of the lung, and there the red cells give up the carbonic acid and other impurities, and take up fresh oxygen. It now becomes of a bright red colour, "arterial blood," and returns purified to the left side of the heart, to start on its journey through the body once more. It is found that in 100 volumes of impure venous blood, there are ten volumes of oxygen, and 46 of carbonic

acid, while in the purified blood, there are 20 volumes o oxygen, and 39 of carbonic acid, a very marked change.

Changes in the air.

It is obvious that with this change in the blood, equally marked alterations must be taking place in the air, and it is found that the expired air now contains a large quantity of carbonic acid and other impurities, as is shown in the following table :—

Oxygen	16·033
Nitrogen	79·557
Carbonic Acid	4·038
Organic Matter	·372
	100·00

The oxygen has sunk from 20, to 16 per cent., and the carbonic acid has risen from ·04 to over 4 per cent. At the same time a very important impurity has been added, namely *organic matter*. Further, a certain amount of *water* passes off from the lungs, equal to about half a pint in twenty-four hours.

Expired air, therefore, differs from pure air in the following particulars.

(1.) It contains **more Carbonic Acid Gas.**
(2.) It contains **less Oxygen.**
(3.) **Organic impurities** have been **added.**
(4.) The **watery vapour** is **increased.**

Effects of breathing impure air.

You can now readily understand the necessity of having a sufficient supply of pure air, and how easily it becomes contaminated if there are a large number of people in the same room, breathing the air over and over again. Some of you may have observed that if you have been for any length of time in a crowded church or hall, or room, the air becomes hot and close, and you become sleepy and headachy and feel out of sorts. That is due to your brain becoming poisoned by the carbonic acid gas, and the organic impurities.

And if a number of people were locked into a small room, with all the windows tightly closed, gradually the whole of the oxygen would be used up and the people would die of suffocation. This actually happened once in India, when 146 English prisoners were shut up in a small room, now known as the Black Hole of Calcutta, less than 20 feet square. In

the morning 123 were dead, and of the remaining 23 several died afterwards from the effects of the poison which they had inhaled.

Sometimes in old wells, carbonic acid gas slowly collects, and if a person descends into it, he dies quickly from want of oxygen.

But there are other dangers in breathing impure air.

You have already learned that **consumption** thrives in overcrowded badly ventilated rooms, and it is found that when people live in small crowded rooms, the death rate from consumption is very high.

Formerly, when prisons were not properly looked after, **Typhus** or Gaol fever, a germ disease, was very common, but it is now almost unknown.

Then the air may become impure through having **dust suspended** in it, and in coal mines and in certain trades, knife grinding for example, the lungs become diseased through breathing in the solid particles. The lungs of a person living in a large smoky manufacturing town, are always blacker from this cause, than those who live entirely in the open country.

The passage of **sewer gas** into the air also causes ill health, and a great deal of the sickness of this town is due to the people breathing in impure air at night. The subsoil water carries the contents of the cesspit into the surrounding soil and underneath the houses, and the air rises from the soil inside the houses and contaminates the atmosphere. When I have had to go to some of these houses at night, especially if the air was still, I have often felt the fetid smell of sewage in the yards, and even in the basements of the houses. A general lowering of the vital processes and such conditions as diarrhœa, loss of appetite, sore throat, bloodlessness, etc., are the frequent results.

Diphtheria is another disease which is carried by sewage, but fortunately the germ of the disease does not appear to exist here.

Purification of air.

Human lungs are constantly adding impurities to the air, using up oxygen and giving out carbonic acid, and we would expect to find that gradually the atmosphere would become saturated with carbonic acid gas and unbreathable, and yet if we examine it we find that its composition remains almost constant. How is this?

The **purification of the air** is effected to a large extent by means of **plants.** They have the power of absorbing carbonic acid from the air, and splitting it up into carbon

and oxygen; the carbon is used by the plant for purposes of growth, while the oxygen is given off. By this means a constant interchange of oxygen and carbonic acid gas is taking place between plants and animals by means of which the purity of the atmosphere is preserved.

Then the **winds** tend to distribute the air, and thus by mixing the gases produce uniformity of composition.

This is also aided by what is known as the **diffusion of gases.** If we place two gases in a jar, without shaking them up, we shall find that they slowly mix with one another or diffuse, until a uniform mixture of the two gases results.

Differences of temperature assist the mixture of gases. Air moves from a hot to a cool place, so that the daily changes of temperature cause varying degrees of air movement.

Rain has also a marked purifying effect on the air. As it falls it washes down all suspended impurities, removes all organic impurities, and absorbs some of the harmful gases.

Nature, then, provides the following means for purifying the air :—

(*a.*) The **action of plants.**
(*b.*) **Winds.**
(*c.*) **Diffusion of gases.**
(*d.*) **Differences of temperature.**
(*e.*) **Rain.**

VENTILATION.

In dwellings, nature has to be assisted in the removal of the products of respiration and combustion, and the supply of pure air, and the process by which this is done is known as **Ventilation.** In England and other cold countries, ventilation is a matter of some difficulty, for warmth has to be maintained as well as a supply of fresh air, so that complicated arrangements have to be made to warm the air admitted. Under ordinary circumstances the fire is the usual ventilating apparatus, carrying the impure air up the chimney, fresh air being admitted by the door and windows, or even through the walls themselves.

In this country, however, we are very fortunate, for we have a warm, pleasant temperature, and sufficient ventilation can always be provided for by a very simple arrangement, **keeping the windows open.** This is assisted by some of the natural provisions to which I have referred above, wind, differences of temperature, and diffusion of gases.

Now what is the quantity of air required by each person in a room, and this is of especial importance at night, when an individual remains in one place for a number of hours? You have seen from the table that ·04 per cent., or ·04 cubic feet of carbonic acid gas is contained in 100 cubic feet of ordinary air. We know that when the amount of carbonic acid gas reaches ·06 per 100 cubic feet, a feeling of closeness or stuffiness is perceived, and the atmosphere is unhealthy; and further that a person breathes out ·6 cubic feet of carbonic acid every hour. From this we can calculate that each person requires 3,000 cubic feet of air per hour to keep it at its normal standard of purity. That is to say that one person would require a room 20 ft. by 15 ft. by 10 ft. if the air is not changed more frequently than once an hour. It is found, however, that the air of a room can be changed three times an hour without causing a draught, so that one person might occupy a room 12 ft. by 8 ft. by 10 ft. = 960 ft., provided that there were ventilating openings sufficient to allow the air to be changed three times in an hour.

From this you can understand how unhealthy the practice is which obtains here, of numerous people sleeping in one small room with every door and window shut, and how very impure the air will be in the morning, especially if we have the air from a neighbouring cesspit soaking into it at the same time. When I walk along the streets of this town at night, and see street after street with the windows hermetically closed, I am not surprised that people rise in the morning, unrefreshed, with a headache, or a bad taste in the mouth, and that there is a great deal of sickness in the town.

People in this country are very much afraid of draughts or cold, but there is very little danger from this source. You can cover your body up, or put your bed to one side out of the draught, or arrange the ventilation so that the draught will not fall on you. I believe that one reason why people fear draughts so much here, I mean educated natives more particularly, is the habit of wearing too many clothes during the day. By this means the skin is rendered more sensitive to changes of temperature.

But there is one thing you must remember, namely, that if ventilation is to be effective there *must be two openings*, an **inlet for fresh air** and an **outlet for foul air.** In cold countries the fireplace serves as one opening, and the window as the other, but here fireplaces are unusual. The foul air being generally warmer, rises to the ceiling, and finds its way out best by the top of the window, while the bottom should be open to admit fresh air, or better still, the door should

be left slightly open, and a window in the passage opened, which will ensure a through current of air.

It must also be borne in mind that after dark the lamps used for lighting the room consume a great deal of oxygen, and produce carbonic acid gas, so that more fresh air is required.

Let me emphasize, then, the necessity for keeping your windows open at night as well as by day, if you are to keep your blood and your body in a healthy condition. Do not dread draughts, and do not fear to get malarial fever, as you have already been taught how to protect yourself against the bites of mosquitoes.

LESSON XIII.

THE DWELLING.

We have now considered very briefly the necessity for good food, for a pure supply of water, and for plenty of fresh air if we are to keep healthy, and now we go on to consider another requisite for health—namely, the **dwelling** and its surroundings. The dwelling is very important, and no doubt all of us would like to live in large, lofty houses, but unfortunately our pockets interfere, and if we build a house we must do so according as our money will allow us, or if we rent one we must see that it is within our monthly pay. Still there are certain points which should be borne in mind whether the house be small or large, humble or palatial. In building a house in the Tropics, we have not the same difficulty as we have in European countries. We do not need to keep out the cold, and, consequently, houses need not be built so substantially or so expensively.

What are the requirements in building a house?

A distinguished sanitary authority has given the following conditions as being necessary to ensure a healthy habitation :—

1. A **site** which is **dry,** and an aspect which gives light and cheerfulness ;
2. A **plentiful supply** and frequent removal of **water,** by means of which perfect cleanliness of all parts of the house can be ensured ;
3. A system of immediate and **perfect sewage removal,** which renders it impossible that the air or water should be contaminated ;
4. A **system of ventilation** which carries off all impurities ; and
5. A condition of house construction which ensures **perfect dryness** of the foundation walls and roofs.

All this means that you require the air inside the house to be as pure, clean, and dry as is possible.

Let us consider these briefly in detail.

1. The site.

In a city which has existed for a long time it is not possible to select new sites, so that we must endeavour to bring the existing sites as closely in accordance with the above requirements as possible.

First of all, it is in most cases possible to have the site dry in this town, for, being built on a slope, it lends itself to satisfactory drainage. Every yard should be provided with a *proper gutter* leading out of it, and, if possible, the yard should be paved. A damp subsoil not only favours disease, but is one of the most common causes of impurity of the air in dwellings.

There is one house, for example, in Pademba Road where a spring actually comes out underneath the house, so that it must be constantly in a damp condition.

In order to assist the carrying off of the water, the *street gutters should all be put in proper order*, and I hope to see the day when this will be done in a thorough manner. Of course, in some parts of the town, as in the Grassfields, the land is so low that proper drainage is a difficult matter, but even there I do not despair. Then sunlight is essential, and I have already told you how the rays of the sun prevent the growth of germs. Houses should, therefore, be *built as far apart* as the exigencies of the neighbourhood will permit, and large trees should not be permitted to grow too close to them. These not only prevent the sun getting at the house, but hinder the circulation of air.

2. A good water supply.

The second requirement is a **good supply of pure water** for purposes of cleansing, etc., and this we have already considered.

3. Sewage Removal.

The third condition is a **system of immediate and perfect sewage removal.**

You have already learned how very far behindhand Freetown is in this respect. I have shown you how the old water supply is contaminated by the presence of cesspits, and how the sewage-soaked soil gives off its poisonous emanations into the inside of the houses. This question of sewage removal is a very important one, and a very difficult one to deal with, but it is one which this city must face if it is to

become healthy. Now, what are the conditions as regards sewage removal which exist in this city? So long ago as 1897, I went fully into this matter, and I got my sanitary sergeant to visit every yard in the town, and find out how the people got rid of their excreta. The following was the result: Out of 4,228 premises examined, 57 were found to use the dry earth system, 2,650 cesspits, of which 839 were in bad condition, 286 open pits, and 1,235 were found to have no closets of any description; that is to say, that the people either used their neighbours' closets or any vacant plot of land which happened to be near. You see, then, that out of over 4,000 premises only 1 per cent. have the pail or earth system in use, and these belong principally to Europeans or the public offices.

The cesspit here is generally of a very simple nature. A hole is dug in the ground, a rim of masonry is sometimes placed round the top, a house is built over this, and the thing is finished. No attempt is made at making it watertight, and unless it happens to be excavated in the solid rock, which is sometimes the case, soakage constantly goes on into the surrounding soil, which gradually becomes almost as bad as a cesspit. When the railway was being made, and the earth turned up in the part leading from East Street behind Kissy Street, the stench of the earth was so bad as to make many of the workmen sick. Let me tell you what happened in my own house, the first house I lived in, in Freetown. There was a cesspit actually in the basement of the house, which I had emptied, disinfected, and boarded over. Some time afterwards, when I was on leave, it was found that the house was full of mosquitoes, and it was discovered that the cesspit had got partly filled with water, the planks had got loose, and mosquitoes were breeding in thousands in it. Now where did this water come from? It was the subsoil water, and it is clear that if the subsoil water could get in it could get out, and there would thus be a constant stream of water flowing through it.

I wish to read to you a paragraph from a lecture given by Sir R. Thorne, one of the most eminent of sanitary authorities, in which you will see how strongly he condemns the cesspit system.

"Indeed, it is well known not only that the paving of yards about small cottage and tenement property in towns has, in its results, been shown to be a public health measure of first importance, but also that the value of such a measure has depended largely on the use of a form of pavement which really ensures impermeability. In the next place, it will be clear that organic and decaying refuse should be so dealt with as to prevent its contaminating the soil in the neighbourhood either

of dwellings or of sources of water supply. I need hardly point out in detail what are the points to aim at in securing this end ; but I may, perhaps, usefully approach the matter from the other point of view, and say that the midden privy, which still prevails in so many of our large midland and northern towns, presents every feature that should studiously be avoided. Generally sunk below the surface of the ground, often open to rainfall, always storing up decomposing excreta and refuse in close proximity to dwellings, it provides almost every condition favourable to the production of nuisance, to the saturation of the soil with filth, and to the setting up and maintenance of those very conditions which seem to be essential to the vitality and multiplication of the typhoid bacillus. The fact that with our present knowledge such a structure as the common midden privy should not only still exist in our midst, but be clung to with a perverted tenacity, is, in my opinion, the greatest blot which attaches to English sanitary administration at the close of the nineteenth century. Apart from its sanitary aspect, it is a system as degrading and ignoble as it is foul, and I trust the day is not far distant when we shall look back to it as a barbarism of the past. Firstly, then, let our aim be to maintain such a condition of cleanliness about our houses that the soil shall approach, as far as practicable to the condition of those virgin soils which are inimical to the growth of the pathogenic organism under consideration."

You have already learned the dangers of the cesspit system. I have told you how they can store disease germs such as typhoid and cholera; how the eggs of animal parasites are stored in them ; how flies breed in them and can distribute the germs of disease ; how mosquitoes breed in them when the contents get liquid ; and how they soak into the surrounding soil, and contaminate the air of the houses. Sore throat, bloodlessness, diarrhœa and indigestion result from this, and, as I said in my report for 1902—" To this contamination of the soil, and the resulting impurity of the atmosphere, I attribute much of the debility which affects not only Europeans but natives, apart from any organic disease."

There can be but one remedy for this, and that is the **"closure of all Cesspits,"** and, in time, the subsoil water and the sun would gradually purify the soil.

Methods of Sewage Removal.

But before cesspits can be closed, we must provide some other means of **sewage removal**. The two systems by which this may be done are the **water carriage** system, and the **conservancy** system.

Water carriage is undoubtedly the best, where it can be practically applied, but in my opinion Freetown and the West Coast of Africa is not yet ready for it. It requires a first-rate water supply, and even our new water supply is not sufficient for the efficient flushing of the sewers. It would require an enormous initial outlay, the introduction of a complicated system of sewer pipes and closets in the

midst of a population the mass of which is only partly civilised, and among whom there is an entire absence of the necessary skilled mechanical labour in the way of plumbers and sanitary workmen.

We must therefore consider the applicability of the **conservancy** system, of which four varieties may be mentioned.

1. The **cesspit,** which, as I have shown, possesses every possible evil.

2. The **Privy** or **Midden** system. This consists of a shallow built-in pit, protected from the rain, in which the excreta are deposited, as well as the ashes and dry household refuse. It should be small, so that a frequent removal of the contents is necessary. It should also be paved so as to prevent soakage into the soil. It is an improvement on the cesspit, but has the disadvantage of storing decomposing matter in the neighbourhood of dwellings, and unless it is kept dry, which would be a very difficult matter during the rainy season, is apt to give rise to offensive gases and smells, and breeds flies.

3. The **Pail** system. Each closet is provided with a tub or pail placed under the seat for the reception of excreta. The pail should be firm with a well-fitting lid, and should be air and water tight. At intervals, once or twice a week, they are removed, emptied, and a clean pail substituted.

4. The **Dry Earth** system. This is the best, and consists in the addition of earth to the stools. Dry earth has the power of completely disintegrating fæcal matter, so that it becomes not only inoffensive, but cannot be detected in the soil. The efficacy of dry earth was recognised by the Jews in the sanitary regulations to which I have referred. When the Israelites were travelling in the wilderness, provision had to be made for the removal of excreta, and accordingly in Deuteronomy, Chap. 23rd, 12th and 13th verses, we find the following regulation :—

"Thou shalt have a place also without the camp, whither thou shalt go forth abroad :

"And thou shalt have a paddle upon thy weapon ; and it shalt be, when thou wilt ease thyself abroad, thou shalt dig therewith, and shalt turn back and cover that which cometh from thee."

You observe that the excreta had to be covered up. Fæces on the surface of the ground are offensive and dangerous ; mixed with earth they are innocuous, and rapidly disappear.

The great difficulty, however, in a large town, of adopting the dry earth system is that it is impossible to obtain a supply of dry earth in a suffieient quantity, and this is especially the case here in the rainy season. Except on a limited scale, therefore, it is inapplicable to towns on the West Coast of Africa.

The system which appears to me to be the only practicable one is the pail system. These would be regularly removed, and the contents deposited either in the sea, or in selected places where trenches would be dug to receive them. A trial on a small scale is to be given to this system in Freetown, and if successful I trust it will be generally applied.

Disposal of solid refuse.

Then there is the **disposal of solid refuse** from the yards, such as ashes, sweepings, etc. You have already learned of the dangers of keeping collections of rubbish, decaying vegetable matter, and so on, in your yards, and how they breed germs of all kinds.

In this town the storage of refuse in ashpits is not permitted. The inhabitants are supposed to collect the rubbish daily and deposit it either in the dustbin or the streets, and the sanitary carts then go round and empty the dustbins. I am pleased to say that there has been a great improvement in this direction of late years, and yards are kept in a much better state than they used to be. I hope, however, that in time the Municipality will be able to provide a service of carts which will go round the town, street by street, at stated intervals, say every two days, and collect the rubbish from the houses. Proper **dustbins,** would be provided, for which the householder will pay. This arrangement will do away with the necessity of the unsightly dustbins in the streets. Then, instead of shooting rubbish down at the Battery, or at Bathurst Street, a proper **destructor** should be provided, in which all rubbish would be burned.

So much for dwellings and sewage removal.

4. Ventilation.

The fourth requirement for a good house is a system of **ventilation** which carries off all impurities, but into this I need not enter again.

5. Dryness of house.

The fifth is a condition of **house construction** which ensures **perfect dryness** of the foundation, walls and roof. This is a very difficult matter to obtain in this country, and is a matter more for the architect and surveyor than for discussion here. Houses with verandahs are preferable, as they keep the central walls dry and also make the house much cooler. It is a good thing to have the whole basement of the house cemented, even if you put a wooden flooring over it. It keeps the house dry, and prevents air from the soil coming up. A substantial roof is a necessity, and corrugated iron, with felting underneath it, is the most suitable for this country. The felt is for the purpose of preventing the heat getting through.

In native houses the floor should be raised above the surface of the outside ground. It should be filled in with earth till it is from one to two feet high, and then well beaten down, so as to make it quite hard. There is a tendency to make the windows too small. These should always be as large as is possible. If the roof is thatched it should be seen that it is rainproof, as this is a common cause of damp houses, and we see the result of this in the rheumatism which is so common here.

These are the principal requirements of a good dwelling, and although we cannot do much with existing dwellings we can do a great deal with reference to the construction of new ones, and it is the duty of the Municipality to see that these are constructed with due regard to sanitary arrangements. Formerly no supervision was given to this matter, and people put their houses down anywhere and built them anyhow, but now I am glad to say that this is changed ; plans have to be submitted, considered, and approved of, and I trust that in time many of the insanitary houses will be done away with.

I am afraid I need not say much about the collection of houses which is called a **town.** Here the town was originally very well laid out, but owing to encroachments and neglect some of the streets have been gradually altered. It is essential that we should maintain the streets as wide as possible, and preserve open spaces such as the Victoria Park, so as to allow of the circulation of air.

LECTURE XIV.

CLOTHING.

Clothing is required for several purposes, 1st, to **protect the body from injury**; 2nd, **to preserve the temperature of the body**; and 3rd, for **purposes of ornament.**

Of these the most important is that connected with temperature. The value of a clothing material depends upon its conducting properties with regard to heat. A **good conductor** is a substance through which heat travels rapidly, for example, metal. If we heat one end of a bar of iron, we find that the other end gets very hot too. Iron, then, is a good conductor. If on the other hand we heat, or even burn the end of a piece of wood, the other end will not readily get hot. Wood is a bad conductor. And similarly, the materials of which clothing is composed, vary much as to their powers of conducting heat, and advantage is taken of this to keep ourselves warm or cool. Now in this country we are favoured by nature, for we have not a winter with its snow and frost, to contend with, and consequently our bodies do not require so much protection. In cold countries, where the temperature of the air is much below that of the body, clothing is worn to keep us warm; in hot countries it is in addition, a protection against the rays of the sun, and helps to keep us cool.

The body loses heat in several ways, by the skin, by respiration, and by the excreta.

The skin is the most important, heat being lost by radiation from the surface of the body, and by evaporation. The moisture of the skin—the sensible and insensible perspiration—evaporates, and in doing so absorbs a large amount of heat from the body. That is why we are so apt to get chills, if we stand in a cool breeze when we have been perspiring, without being properly protected. Clothing then should be of such a nature as to **absorb perspiration.**

Clothing should be **light,** and this is especially the case in this country, where heavy clothes produce excessive perspiration. There is a tendency among civilised natives to wear too much clothing, and sometimes when I have had to examine a man, I have seen him take off a heavy tweed coat, a waistcoat, a heavy shirt, and then a thick undervest or two, which is far too much for a tropical climate. A thin flannel shirt, a coat, and perhaps a light waistcoat are quite enough.

Clothing should also be **loose.** Air is a bad conductor of heat, and if there is a layer of air between the skin and the clothes, heat is prevented passing in or out. In the same way loosely woven fluffy materials, which contain much air between the threads, are warmer than closely woven ones.

It should be **porous**, so as to allow of the evaporation of the perspiration. Waterproof clothing is very hot, owing to the interference with evaporation.

Materials for Clothing.

From animals we obtain wool, silk, leather, etc., and from the vegetable kingdom, cotton and linen.

Silk is derived from the silkworm, and is a very excellent material, but it is too expensive for everyday use. It is a bad conductor of heat, while at the same time it feels light and cool, and is soft and non-irritating to the skin.

Wool is one of the most useful materials at our disposal, and is especially serviceable in a hot country, owing to its power of absorbing perspiration without getting wet. It is a bad conductor of heat, so that a very thin garment of wool is sufficient in this country to keep a person warm, and at the same time it is light. Wool should always be worn next the skin, especially if a white shirt or cotton or khaki clothing is worn.

It has the disadvantage of shrinking when washed, and of being somewhat irritating to sensitive skins. Custom, however, will entirely overcome this irritability.

Cotton is derived from the fibres surrounding the seeds of the cotton plant, which grows naturally in this country. It is a good conductor of heat, and quickly becomes wet with perspiration. Evaporation soon causes it to become cold and clammy, and a chill is very apt to result. For this reason it is not a suitable material for underclothing in this climate. White cotton drill, however, is very good for outside wear, as it is cool, providing that thin woollen underclothing is worn next to the skin.

Linen is obtained from the flax plant. It has much the same objection as cotton, but is even a better conductor of heat.

Colours.

This is important in a warm climate, as colours have different powers of absorbing heat ; white absorbs least, and black most. Clothing in a hot country should therefore be not only light in weight, but of a light colour.

Amount.

You have already been warned of the danger of wearing too heavy clothing in a tropical climate. There is an exception to this. Children require to be protected from changes of temperature more than adults, and yet we find that exactly the opposite practice is generally the case here. Babies and very young children are insufficiently clothed, with the result that coughs, and lung disease are common.

Old people, and the delicate and feeble, require more protection than healthy adults, as the circulation is less vigorous, and the power of heat production, smaller.

Cleanliness of Clothing.

It is essential in this climate that the clothing, especially that which is worn next the skin, should be frequently washed. If this is not done, it becomes full of perspiration, turns sour, germs breed in it, the skin is irritated, and skin diseases such as prickly heat, ringworm, etc., are produced.

Personal Hygiene.

But, in addition to the general principles of sanitation, there are certain points which relate essentially to the individual, to which your attention should be specially drawn. These may be described as **Personal Hygiene.**

Of many of them you have incidentally learned in the course of these lectures.

Food should be taken regularly, and in moderation, should be chewed well and eaten slowly.

The **evils of alcohol** have been described to you, and the necessity of the greatest moderation, or preferably total abstinence, impressed upon you.

The use of **tobacco** is one which to a large extent must be regulated by the constitution of the individual. In youths it is most certainly harmful, interfering with nutrition and arresting growth. In the adult it is not necessary, but in many people it has a beneficial and sedative effect on the nervous system.

Personal **habits** should be regular. The necessity of **personal cleanliness** has been more than once insisted on in its relation to the causation of disease. For this the free use of water is essential. A daily bath should be taken, and in this tropical climate, where the functions of the skin are very active, the frequent use of soap is necessary, for the removal of the waste products which accumulate on the surface of the body. Warm water is better than cold for

cleansing purposes, and hence a warm bath with soap should be taken once or twice a week. In delicate constitutions it may sometimes be advisable to avoid the cold bath altogether. The hands and face should be frequently washed, the former especially before meals, as the germs of diseases may thereby gain access to the food.

The **teeth** should receive special care, as upon their satisfactory action depends the breaking up of the food. They should be cleaned once, or better, twice a day, in order to prevent food accumulating in the interstices of the teeth, and becoming decomposed there. You cannot have a better toothbrush than the "chew-stick," which is so commonly used on the West Coast of Africa. All hollow or decayed teeth should be at once attended to, filled if possible, if not removed.

Great attention should be paid to the **state of the bowels**. They should be freely opened at least once a day, and a habit can easily be formed of having them opened every day at the same hour. After the early cup of tea is perhaps the most suitable time. The habitual use of strong purgatives is to be avoided, and habitual constipation can generally be remedied by regular exercise, fruit and oatmeal.

Exercise should be regular and systematic. By means of exercise the heart beats more strongly, and an increased supply of blood is thus sent through the body. The breathing is quickened, more oxygen is thus drawn into the lungs, and more carbonic acid expired. The skin acts more freely, perspiration takes place and waste products are thereby got rid of. Owing to the muscles being used, they get firmer and harder, the appetite and digestion are improved, and the general tone of the body increased. I am sorry to observe how very little exercise is taken by the youths of this country. This may be partly due to the lack of proper playing grounds, and to the prolonged rainy season, but this is no reason why cricket, tennis, football, and other games should not be more played than they are at present. Gymnastics too should be encouraged.

As exercise is necessary, so a proper amount of **rest** is required for the health of the body, so that the fatigued muscles, brain, and other organs may become renewed. This is obtained by **sleep** the amount of which depends upon the age and the individual. Young people require much more sleep than old people. An infant requires about sixteen hours of sleep, a child of twelve about ten hours, and a healthy adult about seven to eight hours. Night is the best time for sleep, and the bedroom should be quiet, airy, and well ventilated. It should not be full of furniture or boxes as is too often the

case here. Bedsteads should be used, as sleeping on the ground interferes with the circulation of air round the individual. Sleeplessness should be treated by exercise and by endeavouring to remove the cause.

CONCLUSION.

We have now come to the end of our course. Beginning with a definition of Hygiene and Sanitation, and their objects and results, we have studied the general causes of disease, and their relationship to special diseases, proceeding then to consider certain general conditions which affect the health. In doing so we have observed how intimately all these things are related to one another, how the causes of disease only flourish where the surrounding conditions are favourable, how purity of air, water, etc., are conducive to health. Let us, in closing, try to condense what we have learned under three or four chief heads.

We have learned then—

1. That cleanliness in everything, and in every direction, is a very important factor in maintaining health.
2. That germs and animal parasites can be diminished by cleanliness.
3. That in a tropical country the extermination of mosquitoes is essential.
4. That proper surface drainage is conducive to health.
5. That a pure water supply is a necessity.
6. That a perfect system of sewage removal is absolutely necessary.
7. That our bodies require pure air and good food ; and
8. That regularity of life and moderation in all things conduce to a healthy existence and length of days.

If we have grasped these facts, we have learned much. Some of them require the expenditure of money, and we must remember that no sanitary improvements have ever been effected without this, and if we desire health we must be prepared to spend money. But many of these things are in your own hands. It is for you by your personal efforts and your teaching, to carry into effect the lessons you have learned here. Do not be discouraged if your efforts at first meet with little result—ignorance and prejudice are hard to combat—but remember that if you clear even one yard of mosquitoes you have done something. Knowledge will spread surely if slowly, and when at last we have made Freetown a health resort, it will be a source of pride to you, as it will be to me, to know that we have contributed something to this happy result.